Frank E. Graham

101 Metal-Working Projects

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A Guide In Shopwork For Students
In Secondary, Continuation, and Vocational Schools

By

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PREFACE

The purpose of this book is to present in ready form, (1) a source of practice exercises for the teacher of metal work, (2) work specifications for shop directions, and outside preparation for the student.

The author's many years of experimentation and observation as toolmaker, draftsman, university student, and teacher of art-metal work and machine-shop practice to high-school and university students, furnishes the background for the book.

The series of 101 metal projects, each a separate unit with complete working drawings and directions, is so arranged that the beginner starting with the first problem, upon its completion, will find that he can put this experience to practical use in the second problem, and so on through all the jobs. The sequence, however, need not be adhered to rigidly when omission seems to be advisable.

It is firmly believed that the methods of the projects and their sequence in the book are based upon principles that are pedagogically and practically sound. Each project was put through the careful test of time and experience before being given a place in the series.

By analyzing a metal trade, a list of the fundamental operations involved in it may be compiled. This list can then be used as a guide in determining what should be taught in a shop course. Accordingly, a project is selected and designed with a definite objective in view for the student, which, when attained, will smooth the way in the operations that are to follow.

The lessons given call for tools, electrical contrivances and machine equipment that are useful, and of intrinsic value. This fact is of no small consideration to the student. He will naturally study such a book with keen interest and come to the shop ready for work.

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101 Metal-Working Projects

SHOP HINTS

1. Before starting shopwork, roll up your sleeves and put on overalls. Clothes are easily soiled.

2. Do not handle a machine to which you are not assigned; iron will rust.

3. Avoid all unnecessary talking; time is precious.

4. Courtesy demands that you refrain from passing remarks concerning the troubles of others. You may soon have some of your own.

5. Learn to work in harmony with your mates. Remember that their rights and privileges are the same as yours.

6. Be loyal, faithful, and honest. It makes for success.

7. If you need information, look it up, or ask the person in charge.

8. Keep your place of work in a clean, orderly condition.

9. Be thoughtful and deliberate. Definite thinking beforehand prevents many mistakes.

10. Study how to do your work the shortest, quickest, and easiest way to obtain the desired results.

11. Pay special attention to what is going on at the present moment; by so doing, you may prevent the spoiling of work and perhaps serious injury to yourself.

12. Study your machine, the relation of the different parts, and how they can be adjusted.

13. Have your machine properly oiled, and run it at correct speed and feed.

14. Learn what is the correct shape of your cutting tool, and how to sharpen and set it.

15. Return a tool to its place when through using it. Make a report of broken or defective tools.

16. It is dangerous to set a tool when the machine is in motion. If a machine is set wrong, it may spoil valuable work.

17. Keep a proper distance from any machine that is in motion. If you get in the way of a machine, it will punish you with extreme severity.

18. Never put your fingers in the way of a machine for fun; in short, never play with a machine at all, it will not stand a joke.

19. Do not score the platen of a planer, nor make holes in the table

of a drill press, nor gouge the footstock or vise of a milling machine, nor run a lathe tool into a face-plate or arbor.

20. Do not throw files into a heap or on other tools, or rap the chips out of your file on the lathe shears.

21. Machine parts are made of soft iron; do not mark nor nick them in any way.

22. Do not jam a finished piece of work in a vise or under a set-screw; use sheet brass or copper to shield it.

23. Slides and other exposed bearings should be wiped clean before oiling. Oil a newly bored hole before inserting a mandrel.

24. Don't run a chuck or faceplate up to the shoulder suddenly, it strains the spindle and threads, and makes removal difficult.

25. Before putting a chuck on the head spindle, drive out the center by using a rod, and put a piece of rag in the spindle hole to exclude dirt.

26. Never throw in back gears nor throw them out while the lathe spindle is running.

27. Never throw the reverse gear in nor out while the lathe is running.

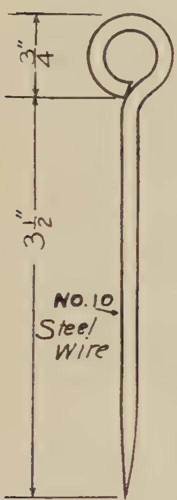
28. Never connect, nor disconnect, change-gear bracket gears with stud gear when the lathe is running. Turn the lathe spindle by hand, forward, not backward.

29. Before starting a lathe, make sure that the centers are in alignment, that the arbor or shaft centers are lubricated, and that the tail-stock spindle is properly adjusted and locked.

30. When quitting work, make sure that tools and work are clean and put in their places, that your machine and bench are clean and in perfect condition.

Problem 1
SCRIBER

Subject and Uses: To locate points or to draw lines on metal, the mechanic employs a sharp steel tool with a stem serving as a handle. This tool is called a "scriber," and is made with a circular eye at the top of the stem.



SCRIBER

Object of Lesson: Holding in vise; filing; "eye" forming; bending; tempering.

Tools and Equipment: Vise; file; ½-in. round piece of metal.

Material Required: No. 10 steel wire 6¾ in. long.

Procedure:

1. Grip the wire in the vise, holding it vertically, so that it projects ⅛ in. above the jaws.

2. Hold the file handle in the palm of the right hand with the thumb on top; grip the other end of the file with the two first fingers of the left hand underneath and the thumb on top pointing toward the handle. File the end of the wire flat, and perpendicular to the axis of the wire, taking long, effective strokes. Press down on the forward strokes only.

3. Place a ½-in. rod vertically in the vise; grip the squared end of the wire between the rod and one of the vise jaws; bend the wire around the rod one whole turn.

4. Remove the rod; place the wire coil flat between the vise jaws, pressing the coil into a plane, to form a closed loop.

5. Replace the rod in the wire loop. With the rod parallel with and between the upper edges of the jaws, and with the wire stem pointing upward, grip the loop so that the top edges of the jaws press the wire at a point just one turn from the squared end of the wire; now bend the stem away from the loop until its direction is that of the radius prolonged.

6. Grip the stem in the vise so it makes an angle of 15 deg. with the horizontal, letting the end project ⅛ in. above the jaws; file the wire, tapering down to the axis at the end, a flat taper for 1¼ in. from the end.

7. Turn the stem upside down, and file a flat taper, symmetrical with the previous one.

8. Repeat this process on the two remaining sides, forming a four-sided pyramidal taper to a point.

9. File down the sharp edges to form a regular eight-sided pyramid.

10. Continue doubling the number of faces by filing down the edges.

11. Press the loop together to a circular closed eye, with the stem in a radial position and straight.

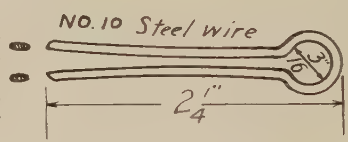
12. Harden the point. Temper it to an orange color, if the metal is tool steel; if it is machine steel, heat it to a bright red, rub it on powdered potassium ferrocyanide, reheat, and quench in oil.

QUESTIONS

1. Describe different kinds of wire, their uses, and their properties.
2. By what process is wire produced?
3. What coats are put on the wire, and how is this done?
4. How is wire measured?
5. What length of No. 8 wire is required for a ring, ¾ in. inside diameter?

Problem 2
SPRING COTTER

Subject and Uses: The advent of the automobile has popularized the cotter pin through its extended use for safety in locking nuts on the bolts that secure vital parts. In making the cotter pin, the prongs should be so shaped, that when two are pressed together, they form a circular cross section. Each prong is flattened until its thickness equals half of its width. This also will serve to harden the prong slightly and make it springy.



SPRING COTTER

Object of Lesson: Spring hammering; flattening; bending.

Tools and Equipment: Hammer; anvil; 10d nail; file.

Materials Required: 4¾ in. of No. 10 steel wire.

Procedure:

1. Hold the wire on the anvil with the left hand; hammer the wire to a uniform width equal to twice the thickness.

2. Bend the wire in the middle until the ends meet.

3. Put the 10d nail in the bend of the wire; grip the wire close to the nail and compress the prongs.

4. Round off the ends of the prongs with a file.

QUESTIONS

1. Describe the nut that is locked with a cotter pin.
2. What metals are made springy by hammering?
3. In hammering it, how does the rate of increase in the length of wire compare with the increase in the width?

Problem 3
TWEEZERS

Subject and Uses: Useful tweezers of good quality may be made from worn-out hack-saw blades. They furnish an excellent exercise in the

manipulation of thin tool steel, hot; and when correctly made are very convenient for picking up or holding small screws, tiny weights, fine pins, or other small objects.

Object of Lesson: Heating; annealing; bending; shaping; sharpening tool steel.

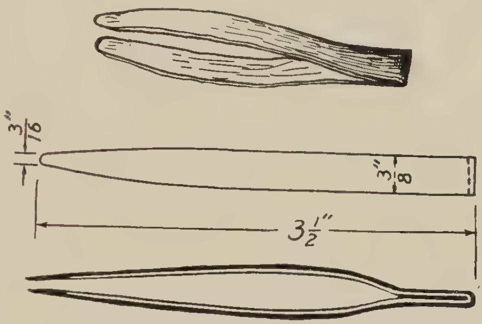
Tools and Equipment: Gas burner; pliers; hammer; file.

Materials Required: Worn-out hack-saw blade.

Procedure:

1. Get an old hack-saw blade about 8 in. long.

2. Heat it red-hot in the middle, grip it just to one side of the middle point, bend it double, and squeeze it together ¾ in. from the end of the doubling. This is to be done quickly with two pairs of pliers.



DETAIL OF TWEEZERS

3. Hold the metal in the vise, and file the edges to a pointed shape as shown in the drawing.

4. Round off the pointed tips, and file them thin to a knife edge.

5. File fine creases, close together, across the inner faces, from the tips back for ¼ in.

6. Heat the tweezers to a dull red, and shape the prongs to the curve indicated, with the tips almost parallel.

7. Polish all over to a smooth finish.

8. Heat the tweezers to a cherry red, and plunge them into oil to cool.

QUESTIONS

1. Why should tweezers be made of tool steel?
2. Is there danger of burning thin steel?
3. Why does a red-hot blade cool off so rapidly?
4. Will the blade crack if it is bent when below red-heat?
5. Would mild steel, of the same dimensions as the blade, crack, if bent when cold?

Problem 4

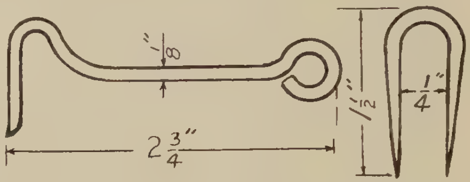
DOOR HOOK AND STAPLES

Subject and Uses: A hook is a convenient fixture for fastening gates, doors, windows, and similar furnishings. The hook is attached by a staple through an eye at one end. The other end of the hook is curved to engage in a staple or screw eye.

Object of Lesson: Measuring; filing; complex bending; pointing.

Tools and Equipment: File; vise; 12d nail.

Materials Required: No. 8 coppered steel wire 11½ in. long for the hook; 2 staples.



DETAIL OF DOOR HOOK AND STAPLE

Procedure:

1. Cut off a piece of wire 4¾ in. long for the hook and 2 pieces 3¼ in. long for the staples.
2. Bend the staples to a ¼-in. opening.
3. File the points to taper 1 in. long.
4. File the end of the wire for the hook square, and bend the eye around a 12d nail, as in Problem 1.
5. Grip the eye and the stem horizontally in a vise, with wire end at the eye down; at a point 2 in. from the eye, bend the wire upward to a 45-deg. angle with the stem.
6. At a point 2½ in. from the eye, bend the wire downward to make a right angle with the stem, thus forming the hook.
7. Bend the end of the hook so as to curve out slightly and file to shape as shown in the drawing.

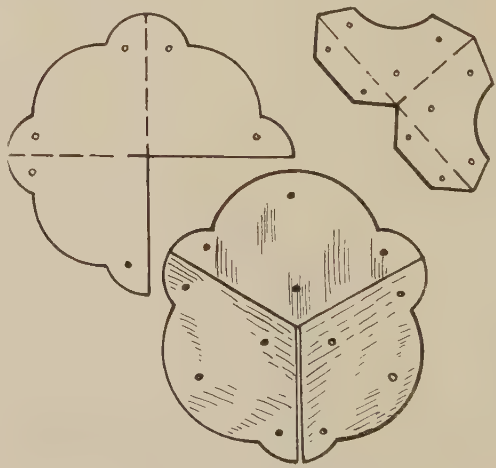
QUESTIONS

1. How is the size of wire measured?
2. How are wire nails measured?
3. How are wood and machine screws measured?

Problem 5
BOX CORNERS

Subject and Uses: To enhance the appearance, or to strengthen construction, corners of boxes and chests are sometimes reenforced with metal corners which serve as trimming, or to bind ends and sides together. They also protect the corners against bad bruises or breakage.

Object of Lesson: Pattern design; sheet-metal cutting; punching; bending.



DETAIL OF BOX CORNERS

Tools and Equipment: Scissors; snips; punch; hardwood block; vise.
Materials Required: No. 24 sheet copper.
Procedure:

1. Determine the size of corners that will harmonize with the size of a given box.

2. Make several corner designs. Cut paper patterns of the corners and try them on the box. Select the best corner design which you have made.

3. Place the paper design on the metal, and with a scriber trace the outline; also draw lines where the metal is to be bent, and cut the metal on the outline.

4. Grip a hardwood block of definite rectangular shape in the vise, and bend the metal corners to the required angles over it.

5. Hold the metal on the end grain of the wood, and punch in holes which have been carefully laid out and spaced to harmonize with the outline of the metal.

6. File off all burrs and sharp edges, and polish the metal to a high degree of finish.

QUESTIONS

1. Where are the weak elements in the construction of a box?
2. How do metal corners make a box stronger?
3. Should metal trimming be fastened by screws, or escutcheon pins?
4. What feature in the metal trimming adds the most to make it ornamental?

Problem 6

NAME PLATE

Subject and Uses: A metal plate on the front door, with the name in raised letters, telling plainly who lives in the house, is a useful ornament. Copper is a metal well suited for the plate. Exposed to the weather it soon takes on a rich dark color and then is not conspicuous.

DETAIL OF NAME PLATE

Object of Lesson: Printing; transferring; raising; making embossing tool.

Tools and Equipment: Hammer; tacks; snips; piece of softwood board of even grain, 3 by 12 in.

Materials Required: No. 26 sheet copper, 2 in. wide, 10 in. long.

Procedure:

1. Print your initials and surname in ⅞-in. vertical Gothic capital letters, spacing the letters exactly.

2. Put carbon paper underneath, and trace the letters so that they appear reversed on the other side of the paper.

3. Paste the name on the copper with the reversed side out.

4. Drive tacks through the copper, near the edge, to fasten it down on a soft board of even grain.

5. Make an embossing tool from a 12d nail by hammering out the pointed end to something like a blunt cold chisel; file the end square; round off all sharp edges so the tool will not cut the copper.

6. With a hammer and the embossing tool, stamp the letters by moving the tool along the outline of the letters, moving the tool half its width for each hammer blow, and so force the metal into the wood.

7. Shape each letter so that it stands out round and full from the under surface of the metal, so that in the completed name plate all letters will be embossed to a uniform depth.

8. Remove the copper from the board and with snips, trim the edges to a neat individual design.

9. As an alternative for step No. 8, mount the name plate between two pieces of ¼-in. board. The front board is to be sawed out, with a coping saw, to the proper size and shape to frame the name plate, and should be chamfered, smoothed, stained, and finished to withstand the weather.

QUESTIONS

1. Where is copper mined?
2. What are the properties of copper?
3. For what purpose is copper preferred to other metal?
4. How may copper be hardened?
5. How is sheet metal measured?

Problem 7
PIN TRAY

Subject and Uses: The tray in this problem is a simple design in drawn or seamless metal work. It illustrates one kind of treatment for a tray, or pan, to take care of the surplus material at the corners when sides and ends are pressed or hammered around a flat piece of metal. The appearance of the tray may be made more interesting by some embossed (raised) work here and there on the flat surface.

Object of Lesson: Cutting; bending; shaping corners; designing surface enrichment.

Tools and Equipment: Snips; flat-, and round-nose pliers; embossing tool.

Materials Required: No. 24 sheet brass, 4¼ by 6¼ in.

Procedure:

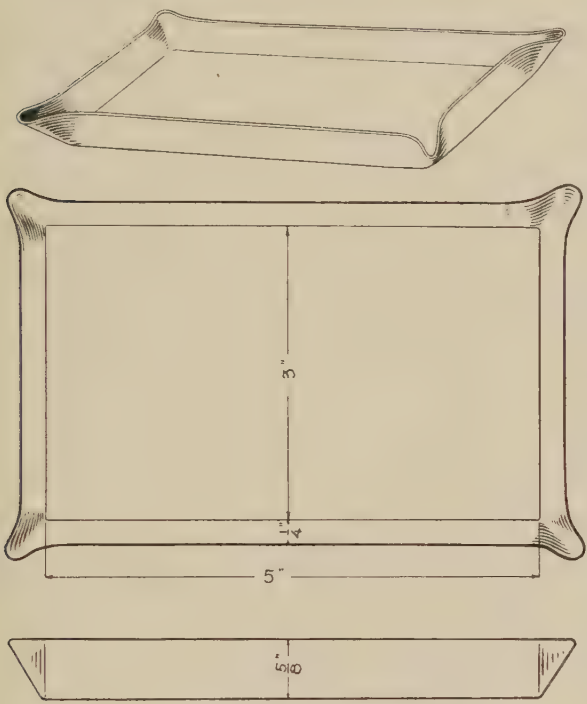
1. Lay out and cut the tray to size, using stiff paper for a pattern. Fold up the sides and the ends to the required slant, at an angle of 60 deg. with the horizontal, and carefully round off the corners.

2. Use the stiff paper pattern as a template. After the shape has been laid out, cut the metal to size.

3. Draw lines to indicate the width of the sides and the ends.

4. Grip the corners with round-nose pliers, and work them into a tapered, semicylindrical shape. At the same time, with flat-nose pliers, bend up and hold the sides and the ends in alignment.

5. Round off the corners, and file all edges smooth.



DETAIL OF PIN TRAY

6. Draw a design on paper as a pattern for raised work to fit the bottom, as a surface enrichment.

7. Place the tray upside down on the end of a block of soft wood of even grain, of the same size as the tray bottom. Draw the design on the metal, and with a hammer and stamping tool, work in the designs to a definite depth.

8. Turn the tray right side up, and flatten carefully around the raised portion to make the design stand out distinctly.

9. The tray may be given an antique color by dipping it in oil and heating it in a gas flame.

QUESTIONS

1. What is the difference between brass and copper?
2. What elements are combined to make brass?
3. In what respect does brass differ from bronze?
4. For what purposes is brass better than steel? Why?

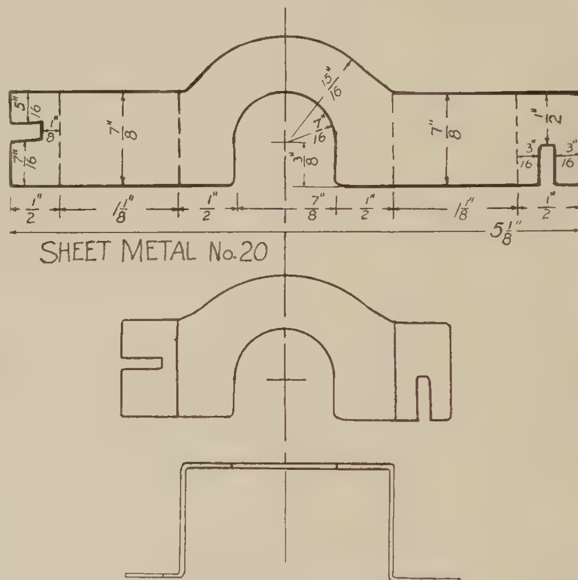
Problem 8
INK-BOTTLE HOLDER

Subject and Uses: A device to prevent an ink blottle from upsetting. It is especially useful to the draftsman who really needs something to steady his India-ink bottle when he pulls out the stopper and quill to fill his pen. Such a holder is easily made and readily fastened to a small, movable wood block, or to a desk or table. The bottles may be replaced by simply pulling one out and pushing another bottle into the holder. The holder also can be slipped off without removing the screws.

Object of Lesson: Punching; filing; cutting curves; bending.

Tools and Equipment: Punch; hammer; file; curved snips; scriber; small cold chisel; pattern.

Materials Required: One piece of No. 20 sheet metal 1½ by 5¼ in.; 2 No. 5, ½-in. r.h. wood screws.



DETAIL OF INK-BOTTLE HOLDER

Procedure:

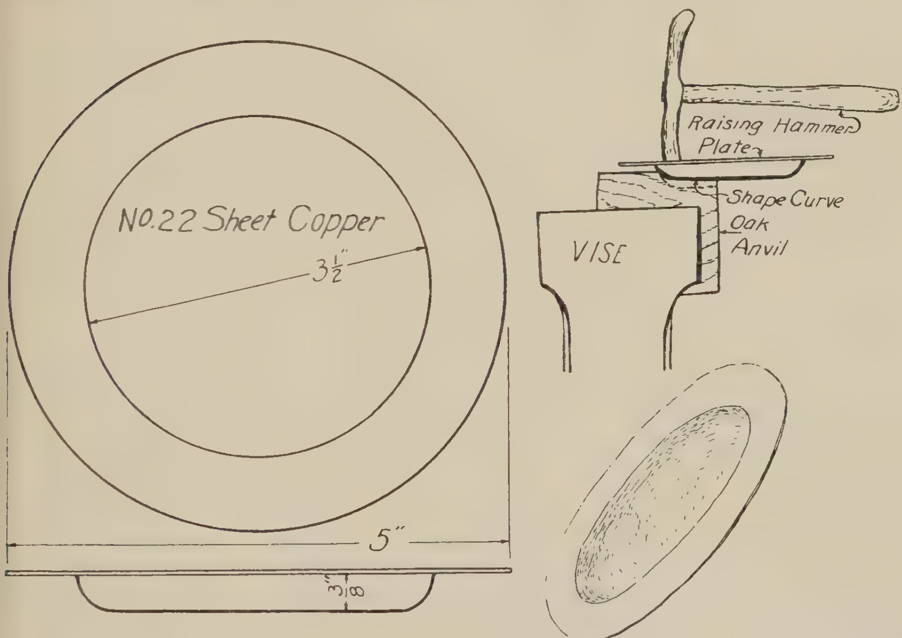
1. Lay out the pattern on paper, and cut it to exact outline and dimensions. Bend the paper pattern to the required shape.
2. Lay the pattern flat on metal, and with the scriber trace its outline and mark where the metal is to be bent.
3. Use snips to cut the metal along straight lines and easy curves, and a small cold chisel to cut out the opening for the neck of the bottle.
4. Punch holes where the slots are to end, and cut slots to the holes, so that the holder feet may be slid into place under the screw heads.
5. File off all burrs, sharp corners, and edges.
6. Bend the metal on parallel lines, first on each side of the center, and then near the ends, to exact measure and to form right angles. Hold the metal in the vise while making the bends.

QUESTIONS

1. Is it essential that the bending lines are parallel? Why?
2. What would result from an error in the distance between the bending lines?
3. What kind of metal should be used for this holder?
4. What is to be considered in deciding on the material to be used for a project of this kind?

Problem 9
CARD SALVER

Subject and Uses: The card salver described in this problem is made of copper. The dish in the salver is made by hammering in the depression to a series of molds cut into a hardwood block, the molds varying in size from a shallow arc to the final or shaping arc. The size and depth



DETAIL OF CARD SALVER

of the plate are matters of choice. If a plate is to have a deeper dish than this card salver, the metal must be correspondingly thicker to allow for the additional metal needed in the longer stretch. As the metal gets harder under the stretching process, to prevent its cracking, it may become necessary to anneal it. This is done by heating the metal red-hot, and plunging it into cold water.

Object of Lesson: Stretching metal into a circular concavity.

Tools and Equipment: Vise; block of hard wood; raising hammer; snips.

Materials Required: One piece of No. 22 sheet copper, 5 by 5 in.

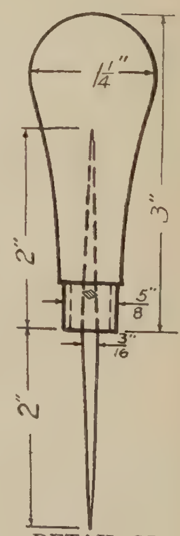
Procedure:

1. Locate the center, and draw two circles on the copper, of 2½-in. and 1¾-in. radii.
2. With snips, trim off along the outer circle.
3. Grip the hardwood block in the vise, and cut away a portion near the corner of the block to form a small curved recess.
4. Place the copper disc on the block so that the portion just inside of the inner circle is over the recess. With the raising hammer, force the copper into the recess with moderate blows, slowly rotating the plate around its center so that a circular groove is formed.
5. Make the circular recess in the wood slightly larger, and placing the copper disc over it as before, continue the raising process by hammering the plate to fit this circular groove.
6. Repeat this stretching process until the desired depth and shape are attained, keeping in mind that the whole inside area must be stretched to meet the increase in the amount of metal required for the downward curved surface.
7. Straighten bottom and edge of salver so edge is flat and of uniform height all around, then file and smooth the outer edge.

QUESTIONS

1. What are the advantages in using a wood block for an anvil?
2. Do the hammer blows stretch or compress the metal?
3. What is the reason for the increased stiffness in the plate?
4. Could a plate of this shape be made of brass? of steel?

Problem 10
BELT AWL



DETAIL OF BELT AWL

Subject and Uses: This awl is substantially made with a handle of ample size, reenforced with a strong ferrule. The handle is turned in a lathe, or it may be shaped with a drawknife, rasp, file, and sandpaper. The blade is sufficiently heavy to resist bending; it has a long taper which offers least resistance in perforating leather or other materials.

Object of Lesson: Handle forming; making a close-fitting ferrule; filing; hardening; tempering.

Tools and Equipment: Drawknife; rasp; file; hack saw.

Materials Required: A piece of maple or cherry wood for the handle 1½ by 1½ by 4 in.; 1 piece of ⅜-in. gas pipe, ⅝ in. long, for ferrule; 1 piece of round tool steel, 3/16 by 4½ in. for blade.

Procedure:

1. With a hack saw, cut off the ferrule and file it to shape, removing the sharp edges.
2. Shape the handle, and fit it to the ferrule. Press the ferrule on the handle. Drill a hole straight into the end of the handle for the awl.
3. File tapers on the blade from the center to both ends. The handle end should have a diamond cross section, and the working end should be circular.
4. Harden and temper the working end to a dark-brown color.
5. Assemble the parts, driving the blade into the handle, straight and solid.
6. Smooth, oil, and polish the handle.

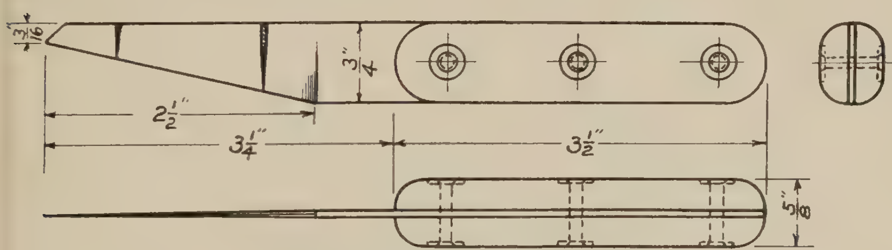
QUESTIONS

1. What are the qualities of a good handle?
2. Why should the blade be made of tool steel?
3. How is hardening and tempering done?

Problem 11

BENCH KNIFE

Subject and Uses: A good bench knife should have (1) a strong blade of good steel, well tempered, ground to the proper angle, and honed to a keen edge; (2) a strong handle with a good grip, securely fastened to the blade. Such a knife can readily be made from scrap or waste materials. Broken, or worn-out, heavy hack-saw blades, or strips of other good steel, may thus be turned to good account.



DETAIL OF BENCH KNIFE

Object of Lesson: Making rivets; forming handle; annealing; grinding; tempering.

Tools and Equipment: Grindstone; forge; rasp; riveting hammer; breast drill; file; whetstone.

Materials Required: Blade: a piece of worn-out blade from a power hack saw, 7 in. long. Handle: a piece of maple or cherry wood, 3/8 by 2½ by 4 in. Rivets: three 8d wire nails and 6 copper burrs.

Procedure:

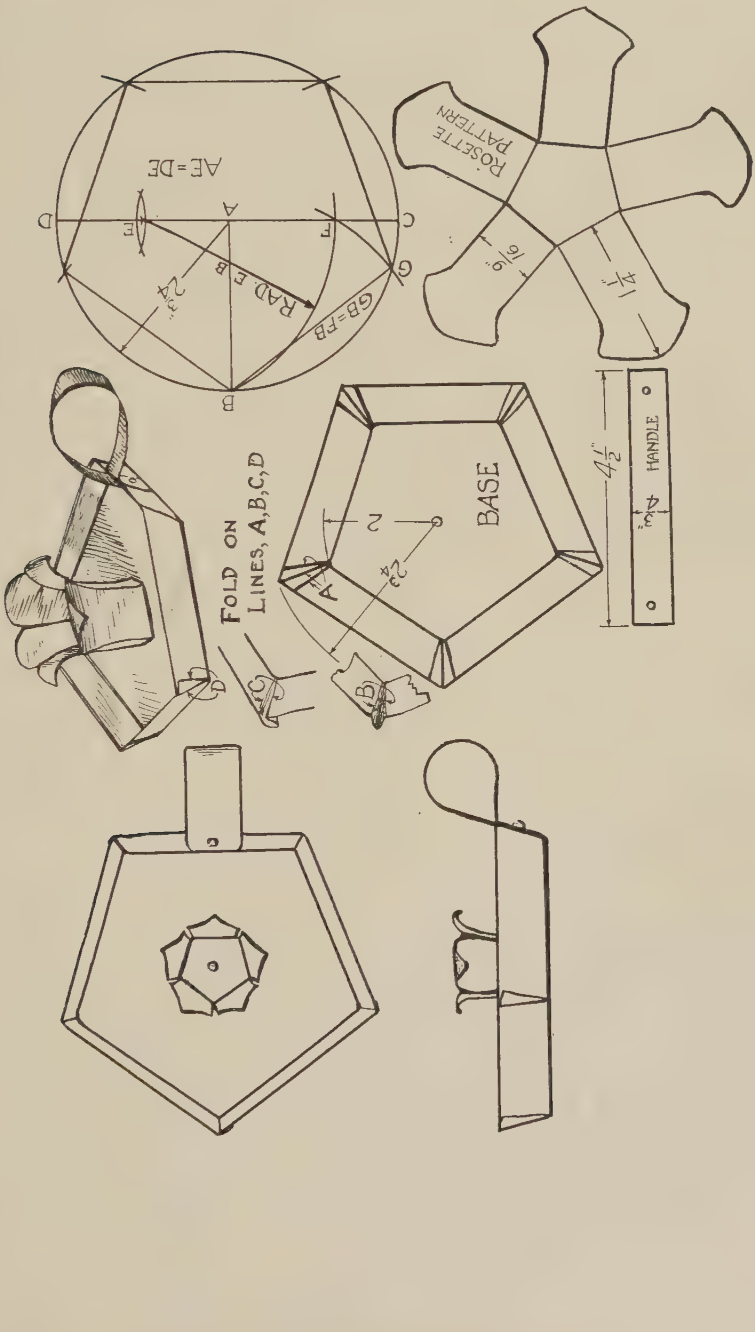
1. Anneal the handle part of the blade by heating it red-hot and then letting it cool off slowly in the air. Keep the cutting end cool and hard, by tying a rag around it, and dipping it into cold water frequently while the handle end is heating. Reduce the hardness of the cutting blade by tempering it to a dark brown.
2. Drill 3 holes in the blade for the rivets.
3. Grind the blade to the proper shape, and bevel the sides of the cutting edge.
4. To make the handle, take 2 pieces of wood and drill 3 holes through each piece. To pair these wood pieces, use the blade for a template.
5. With an auger bit, counterbore holes so that the burrs will fit flush with the surface of the handle.
6. Put the handle on the blade, then put the burrs in their recesses, and insert a nail through one of the holes to get the length for the rivets.
7. Cut off the nails, allowing 1/16 in. for riveting; insert rivets; reset rivet heads on a solid iron support; put burrs in place and hammer down the rivet end with a small cross-peen hammer, using light, quick strokes; draw down each rivet end until it is tight or solid—not too tight or the handle may crack.
8. Grip the handle in a vise and rasp it into shape. Finish with file and sandpaper. Apply two coats of oil.
9. Grind the cutting blade to a keen edge, and whet it on an oilstone.
10. Make a wooden holster with a clip attachment to hook on the belt, in which to carry the knife.

QUESTIONS

1. What is the proper hardness for a knife blade?
2. What will likely happen if the blade is too hard? if too soft?
3. How could knives be made from worn-out hand or band-saw blades?
4. How could a big knife be forged from a broken automobile spring?

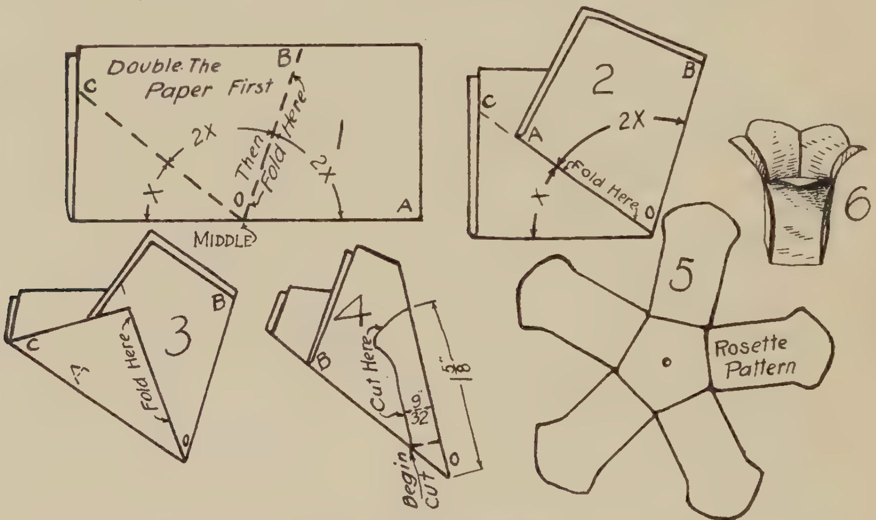
Problem 12
CANDLESTICK

Subject and Uses: So long as the humble candle retains its charm, so long will its inseparable companion, the candlestick, come in for no end of variety in design. The candlestick described in this problem is made of sheet brass. It has a five-sided base. The corners are folded on three lines at the same time that the sides are bent up. In this way, the



DETAIL OF CANDLESTICK

corners are not cut, but the surplus material is squeezed together, bent to one side, and pressed tight against the sides of the base. This is a neat, as well as substantial construction. The rosette (fashioned from the paper pattern which is folded as shown in the drawing) is cut to shape and formed on a five-sided piece of wood. Then it is riveted to the center of the base. The ends of the handle are fitted to opposite faces of a side of the base, and are secured by a rivet.



PATTERN FOR ROSETTE

Object of Lesson: Laying out and making a pentagon base; bending sides; folding corners; forming a rosette; riveting.

Tools and Equipment: Pliers; snips; vise; hammer; punch; file.

Materials Required: No. 24 sheet brass, for base, 5½ by 5½ in.; for rosette, 3¼ by 3¼ in.; for handle, ¾ by 4½ in.; 2 copper rivets ⅛ in. diam.

Procedure:

1. Make a full-size paper pattern, pentagon-shaped, for the base, as follows: Draw two concentric circles of 2- and 2¾-in. radius, respectively. See drawing. Draw diameter CD and radius AB, perpendicular to it. Bisect AD at E. With E as the center and EB as the radius, draw arc BF. With B as the center and radius BF, draw arc FG. Distance BG is one side of the pentagon. Mark off the circle, draw the radii, and connect the points by lines. Cut and fold the pattern.

2. Make paper patterns for the rosette and the handle, full size, and bend the patterns to shape. See drawing. Note the six steps in folding and cutting the rosette pattern.

3. Select the sheet metal; lay the patterns flat on the smallest possible area, and trace around each with a scriber.

4. With snips, cut exactly on the lines, and trim the edges smooth.

5. Draw lines for the sides and the corner folds.

6. With pliers, bend up the sides, press the surplus metal together at the corners, and bend these folds all in one direction against the sides; squeeze the folds flat in a vise. See drawing. Note steps A, B, C, and D in folding corners of the base.

7. Touch up the sides and corners to make the work uniformly neat all around.

8. Bend the rosette into shape on a five-sided wooden block, each side 9/16 in. wide. Bend out the tops of the prongs into shapely curves.

9. Punch the base and the rosette at the centers, and rivet them together securely and smoothly.

10. Punch holes in the handle strip, 5/16 in. from each end, and bend the handle to shape.

11. Use the handle to locate the mark for the rivet hole on one of the sides of the base; punch a hole in the side the same size as in the handle.

12. Rivet the handle on tightly and hammer to a neat joint, rounding the rivet head.

QUESTIONS

1. Give another method for drawing a pentagon besides the one described in this lesson.
2. How may the corners be joined, instead of folding them?
3. Would a riveted corner be as tight and as neat as the folded corner?
4. Would a soldered joint be as strong and could it be as economically made?
5. Why is the base side riveted between the handle ends?

Problem 13
METAL BOX

Subject and Uses: The size for this box may be varied to suit individual requirement. The box may be used to hold stamps or, made in a larger size, to hold valuable papers. It presents a typical box construction that affords experience in fundamental operations such as: mitering and soldering corners; making and riveting down hinges; cutting and piercing ornamental parts.

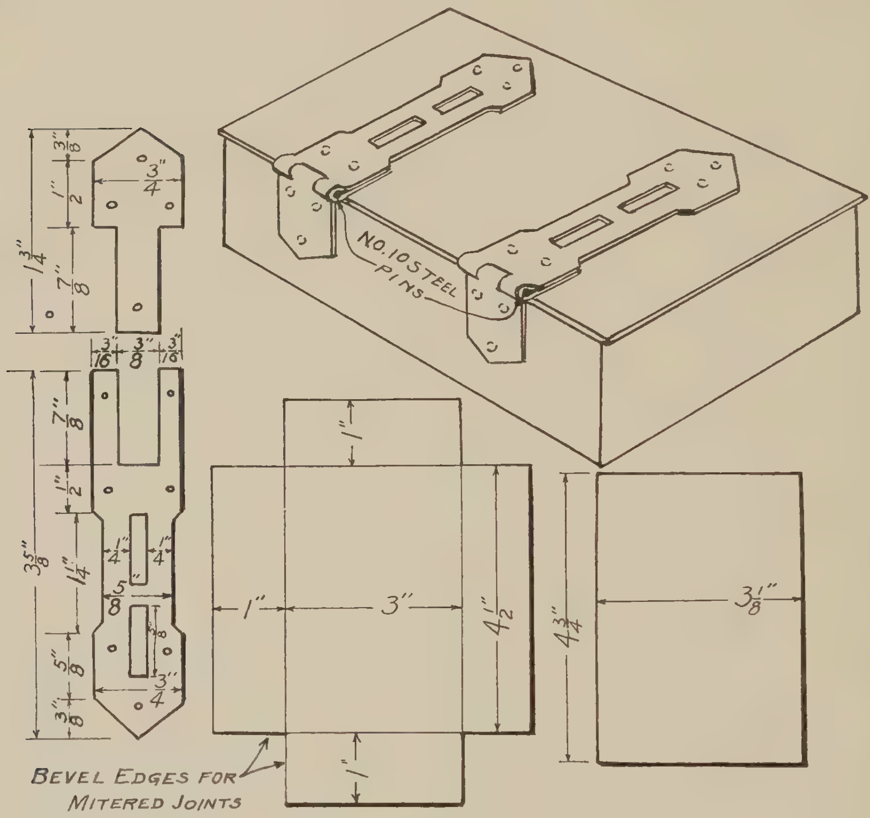
Object of Lesson: Mitering; soldering; drilling; piercing; riveting; making hinges.

Tools and Equipment: Soldering outfit; wire; pliers; breast drill; riveting hammer; snips; small chisel; file.

Materials Required: One piece of $5\frac{1}{4}$ by $11\frac{1}{2}$-in. No. 20 sheet brass; No. 10 steel wire, 2 in. long; 16 copper rivets, 1/16 by $\frac{1}{8}$ in. long.

Procedure:

1. Make drawings to exact measurements of the box, the lid, and the hinges.
2. Cut the paper to the lines, and bend it into the required shape to see that the pattern comes out right.



DETAIL OF METAL BOX

3. Place the paper patterns flat on the metal, and with a scriber trace a sharp outline.
4. With snips and a small sharp chisel, cut out all parts to the line.
5. File the sides and the ends to 45-deg. angles, for mitered joints at the corners.
6. Shape a rectangular hardwood block to fit exactly inside of the box.

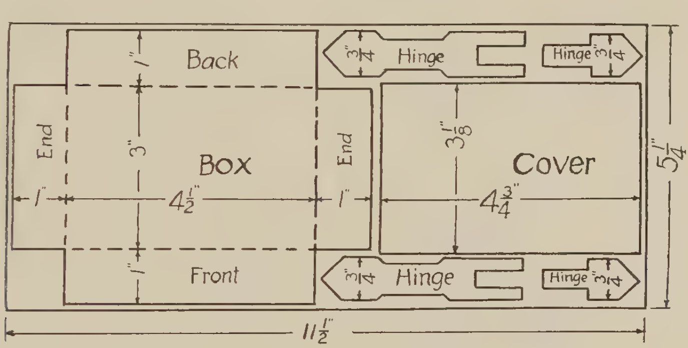
7. Grip the face of the block and the bottom of the box together in a vise; bend down and turn in the sides and the ends over the block.

8. Tie the ends and the sides together, to a tight fit at the corners, with several turns of fine wire.

9. Test the box for correct dimensions and angles, and solder the corners. Use an acid-free paste flux for soldering.

10. Cut the lid to size, and round off the corners and the edges.

11. Cut, file, and bend the hinges into the required shape, fitting them around the pin by pressing them together in the vise.



LAYOUT OF STOCK FOR METAL BOX

12. Center-punch and drill holes so that the rivets will go through a double thickness of metal, on both sides of the pin.

13. Place the lid on the box, space the hinges accurately; mark and drill holes for the rivets.

14. Pierce as shown in drawing and file all parts of the hinges to exact size.

15. Fasten the hinges with rivets, first to the box and then to the lid. The round rivet heads on the outside should be held in a recess drilled into an iron block, while riveting the ends on the inside.

16. Cut and file the overhang of the lid so it will parallel the front and ends of the box.

17. Go over the box in detail to perfect the finish. Polish the box over all.

QUESTIONS

1. Why should the soldering iron be tinned?
2. Will tin stick to an iron that is allowed to get too hot?
3. Why must metal parts be heated for solder to stick to them?
4. Why should rivets be of soft metal?

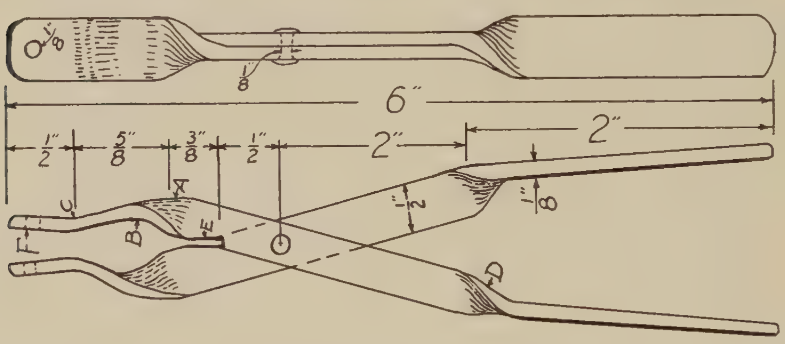
Problem 14

FLAT-NOSE TONGS

Subject and Uses: The use for tongs has increased many times since automobiles and radios have laid claim on so much of our time in assembling and adjusting, altering, experimenting, and rebuilding. The tongs here described are easily made, and are light, durable, and handy. The holes through the jaws are for gripping heads of screws and nails to start them in cramped places.

Object of Lesson: Measuring; twisting; bending, riveting; filing; casehardening.

Tools and Equipment: Vise; monkey wrench; drill; hammer; file.



DETAIL OF FLAT-NOSE TONGS

Materials Required: One piece of flat, soft steel, ⅛ by ½ by 12 in.; for the pivot, a piece of a 10d nail may be used.

Procedure:

1. Cut the stock to two 6-in. lengths. The operations on both are alike.
2. Locate, center-punch, and drill a hole 2 in. from the end in each piece, to fit a 10d nail. Countersink the holes slightly.
3. Grip the stock in the vise at A, 1¼ in. from the short end, and with a monkey wrench at B, ½ in. above the vise, twist the stock a quarter turn.
4. Grip the stock in the vise at B, and bend it through an angle of 45 deg.
5. Grip the stock at C, and bend the jaw into alignment with the main body.
6. At D, grip the handle in the vise, and with a monkey wrench ¾ in. up from the vise, give the stock a quarter turn.
7. At E, file the jaw to a cutting edge, on a radial line from the hinge.

8. Assemble the two members: insert the tight-fitting pivot, and rivet the ends to a round head, with light hammer blows.

9. File fine creases across the inner face of the jaw at F.

10. Drill a ⅛-in. hole through the jaws at F.

11. File the jaw ends and the handle ends round and smooth. Bend the handle to the position desired.

12. Caseharden the jaw and the cutting edge; heat red-hot, and apply powdered bone meal, or potassium ferrocyanide on the part to be hardened; reheat to red-heat and quench it in water.

QUESTIONS

1. Why should a rivet fit close in the hole?
2. Why is the hole countersunk under the rivet head?
3. Why should the end of the rivet be filed square and to proper length before it is hammered?
4. Is it essential that the twists in the metal are in the same direction? Why?
5. Why should the cutting edge on the jaws be filed to an angle less than 90 deg.?
6. Why should the direction of the edge be radial from the center of the pivot?

Problem 15
CLIP PAPER HOLDER

Subject and Uses: The clip paper holder described herewith will be found useful and handy in taking notes, sketching, or drawing. The size of the board may be varied to meet requirements. The tension on the metal clip at the top of the board is supplied by a coil spring, with a long center loop pressing against the clip at its upper end. On each side of this center loop, the spring wire is given three turns around the staple that holds the clip to the board.

Object of Lesson: Bending clip; winding spring; clenching staple.

Tools and Equipment: Woodsaw; plane; snips; pliers; file; hammer.

Materials Required: Basswood board, ⅜ by 9 by 16 in.; No. 24 sheet brass, 4 by 4¼ in.; 1 piece of No. 10 steel wire, 5½ in. long; 1 piece of No. 16 spring-steel wire, 10 in. long.

Procedure:

1. Saw the board to size and finish the ends and sides square; round the two upper corners, and bore a ¼-in. hole at the center ¾ in. from the upper edge.

2. Make a paper pattern of the clip, bend it to shape, and mark it for holes.

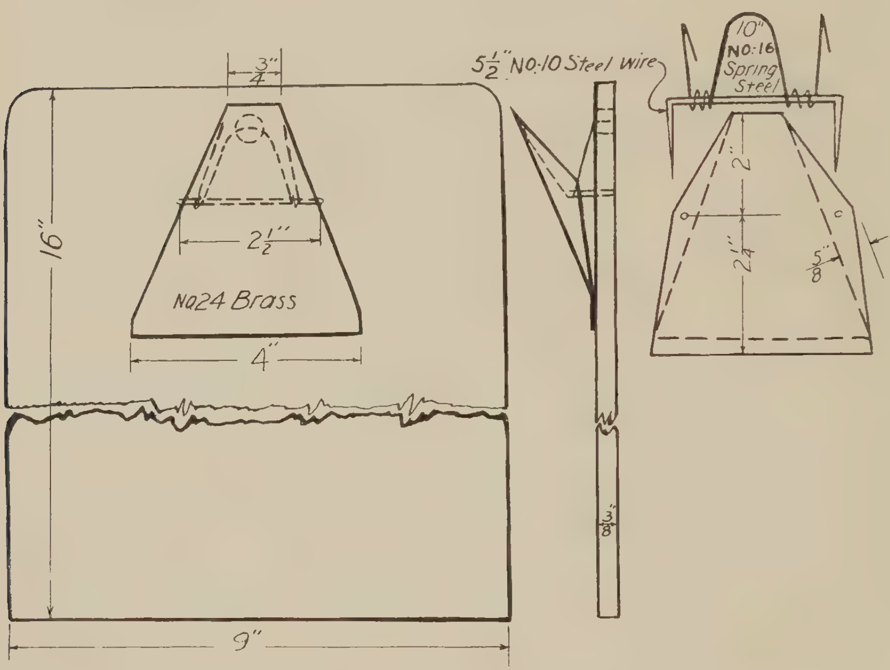
3. Place the pattern flat on the brass, and draw the outlines with a scriber.

4. Cut the metal to the pattern, bend the sides, punch holes, and file all edges smooth.

5. Wind the spring to the required dimensions and shape.

6. To make the staple, file both ends of the wire to a long tapered point and bend the wire at right angles, 1¾ in. from the end, on one end only.

7. Insert the straight end through the hole in the clip, then through the two coils in the spring, and then through the second hole in the clip. Make the second bend in the wire like the first.



DETAIL OF CLIP PAPER HOLDER

8. Locate the position on the board for the clip, force the staple points through the board, bend the ends back to a U shape, and clinch them into the board.

9. Adjust the lower edge of the brass clip to make it bear with equal pressure across its whole length.

10. Slip a sheet of paper under the clip to test for uniform tension at all points, and make the necessary adjustments.

11. Make short right-angled bends at the spring ends, locate their proper position, and drive them into the board.

12. Polish all parts to a bright finish. Shellac the board.

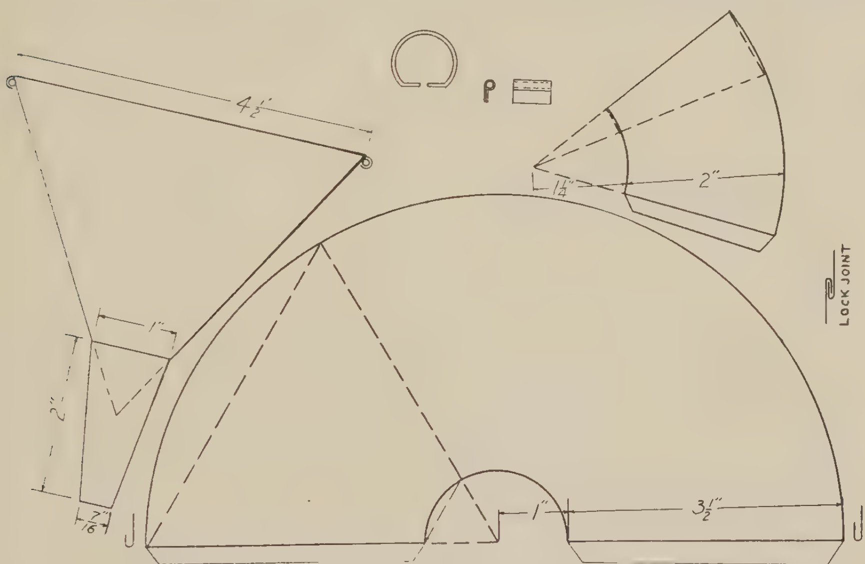
QUESTIONS

1. What is a coiled spring? an extension spring? a compression spring?
2. What is a helical spring? a flat spring?
3. What are the characteristics of spring steel?
4. How is a clock spring made? How does it work?

Problem 16
FUNNEL

Subject and Uses: The conical body and spout of the funnel are developed in a flat pattern, or in a full-size side view, by extending the side lines of the converging sides until they meet at the apex. With the apex as a center, draw two circles, using the slant height to the apex of the upper and lower edges of the funnel body for the radii. From a top view, the circumference is derived, and that distance is stepped off on the larger circle of the flat pattern. The initial and final points are connected by lines with the center.

Object of Lesson: Radial surface development; wiring edge; soldering.



DETAIL OF FUNNEL

Tools and Equipment: Dividers; snips; pliers; soldering outfit; hammer; mallet.

Materials Required: One piece of IX tin or No. 26 galvanized iron, 5 by 11 in.; 1 piece of No. 14 steel wire, 16 in. long.

Procedure:

1. Lay out patterns for the body and the spout on stiff paper, allow-

ing extra material at the upper edge for wiring, 3/16 in. for a lock-joint seam, and 1/8 in. for a lap joint on the spout.

2. Place the paper patterns on the tin, and draw exact outlines on the tin with scribers. Cut the tin with snips.

3. Turn the edges of the body in opposite directions, for a lock joint, and bend these edges over a stake to the required form.

4. Hook the folded edges together to form a neat, tight seam, and hammer it down lightly with a mallet.

5. Form the spout over a small stake, and solder the lap joint.

6. Peen a small flange on the large end of the spout, drop it into the body, push it down in place and see that the spout and body are in proper alignment.

7. Solder the spout in place inside and out; also solder the seam of the body.

8. Turn the upper edge outward, slip the wire ring in place, and close the edge firmly down over the wire.

9. Form a 3/4-in. wire ring, bend a tin clip into shape, insert the ring in the clip, and solder the clip to the upper edge of the funnel, over the seam.

QUESTIONS

1. Of what are tin cans made?
2. What is the coating on galvanized iron?
3. How are tin cans produced at such low cost?
4. Explain the process of making sheet iron.

Problem 17
COPING-SAW FRAME

Subject and Uses: A carpenter, when working on wood trimmings, uses a coping saw for fitting the end of a molding to the side of another molding. This involves sawing curves corresponding to the contour of the molding. The blade of the coping saw is so narrow that it may be guided in any direction, hence it is extensively used in sawing curves in wood. It is especially popular in toymaking, where thin wood is sawed to so many different shapes.

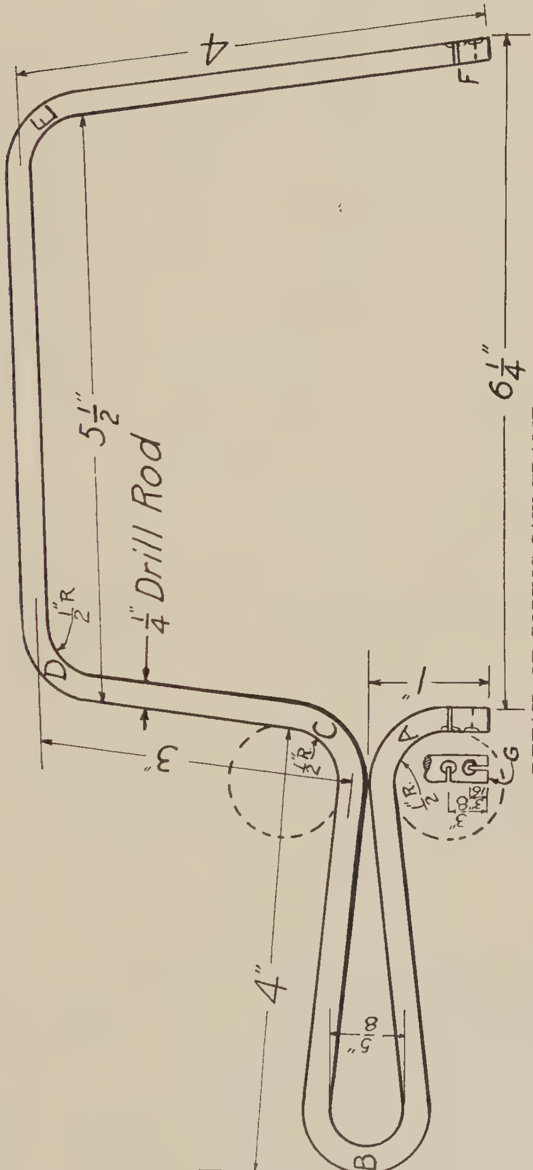
Two slits are cut at each end of the coping-saw frame. One is cut into the end and one into the side, 3/8 in. from the end, so that the blade may cut forward or sidewise.

A shallow impression is made with a drill on the outside of the frame, in line with the slits, for lodging the enlarged end of the saw blade.

Object of Lesson: Measuring; bending; spotting; slitting.

Tools and Equipment: Vise; drill; hack saw; file.

Materials Required: One-fourth inch drill rod, 22 in. long.



DETAIL OF COPING-SAW FRAME

Procedure:

1. Grip the rod at point A, between the vise jaw and a piece of 1-in. round iron, and bend a quarter turn.
2. At point B, bend the rod a little over a half turn around 5/8-in. round stock, so it will come together at point A.
3. At point C, bend the rod a quarter turn so it will be in line with the end of the rod at A.
4. Bend the rod around 1-in. stock a quarter turn at D.
5. At point E, bend the rod around 1-in. stock almost a quarter turn.
6. Cut off the ends of the stock to proper lengths, file the ends square, and break the sharp edges.
7. Locate, center-punch, and drill two depressions 1/16 in. deep at each end of the frame, one 3/8 in. from the end, and the other 3/16 in. from the end.
8. Saw one slit across each end, lengthwise, 3/16 in. deep.
9. On the sides of the ends of the frame, 3/8 in. from the end, saw slits 7/64 in. deep.

QUESTIONS

1. Why should this frame be made of drill rod?
2. How much farther should the ends of the frame be apart than the length of the saw blade?
3. Why are the depressions on the outside of the frame drilled before the slits are cut?
4. Why should the slits, cut into the side of the frame, be sawed to the exact depth?
5. Why is it important that the slits in the frame are cut in direct line with each other?
6. Why should the slit be exactly in the center of the depression?

Problem 18
PAPER KNIFE

Subject and Uses: A paper knife, which also may be used to slit the pages of untrimmed magazines or as an envelope opener, should be designed with a fairly sharp point. It should not be clumsy or large, but it must be stiff and substantial. In the process of beating, the metal not only increases in width and gets thinner, but also becomes harder and stiffer.

Object of Lesson: Designing; hammering; piercing; making monogram.

Tools and Equipment: Metal saw; snips; breast drill; file; hammer.

Material Required: One piece of 1/16-in. copper, 1¼ by 9 in.

Procedure:

1. Draw several different designs and select the best one for your pattern.
2. Make allowance in the pattern for the stretch in the metal when it is hammered.
3. Paste the pattern to the metal, and with a pair of snips cut the metal to shape.

4. Hold the metal on an iron block; with a light hammer beat the blade to tapering edges, leaving it nearly full thickness along the center.

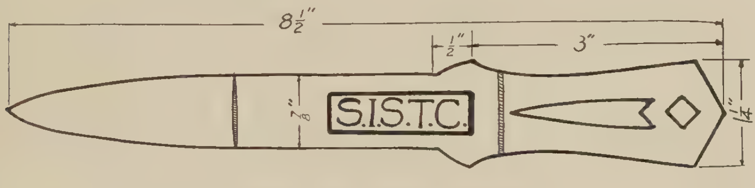
5. Drill a hole to admit a saw blade for each of the cut-outs.

6. With a metal saw, make the cut-outs and then file and smooth the edges in them.

7. Design a monogram of your own initials, or the initials of your school, to fit a space on the hilt of the blade.

8. Warm the metal, and then spread a thin coat of paraffin where the monogram is to be etched.

9. With a steel point, remove the paraffin from around the block letters, and form a background of pleasing shape.



DETAIL OF PAPER KNIFE

10. Apply an etching acid, composed of one part of nitric acid added to two parts of water. Allow the acid to etch the design, 1/32 in. deep. Carefully wash off all the acid and remove the paraffin.

11. Smooth off all edges with a file, and sharpen the blade.

12. Polish the whole surface, except the sunken portion of the design, to a fine luster, and apply a coat of banana oil to prevent tarnishing.

QUESTIONS

1. What metals will tarnish? What causes tarnishing?
2. How may iron be protected against rust?
3. What is the action of acid on metal? How may the action be stopped?
4. Is it injurious to health to inhale fumes from acid?

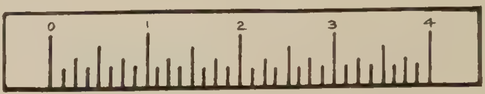
Problem 19
BRASS SCALE

Subject and Uses: The reliability of this scale depends on the accuracy with which every detail of the procedure is carried out. The tool is graduated by the use of trammel points to transfer the marks from another scale. One of the points is held on the mark on the standard scale, while the other point is made to scratch a short line through the paraffin on the brass scale. The two scales are clamped down on a table. Their edges must be in a straight line, and about 5 ft. apart. (The beam of the trammel points is 5½ ft. long.) The brass strip is 5 in. long, and is graduated into sixteenths for 4 in. on one side, and into millimeters

for 10 centimenters, on the other side. The graduation marks should correspond in length with those of a standard scale, which also applies to the position of the numbers.

Object of Lesson: Graduating; etching.

Tools and Equipment: Trammel points; 4 hand clamps; fine file; paraffin; scale.



BRASS SCALE

Materials Required: One piece of brass, ¾ by 5 in., 1/16 in. thick.

Procedure:

1. Straighten and flatten the metal, and drawfile the faces and edges to make them parallel, straight, and smooth.

2. Put small pieces of paraffin on the metal, and warm the metal so a thin coat of the paraffin covers the whole face.

3. Clamp down the two scales, 5 ft. apart and in line, and so as not to obstruct the moving of the trammel points.

4. Have the trammel points sharp, and the length of beam carefully adjusted so that the lines may be fine and exactly spaced, and the end margins may be equal on the brass scale.

5. Let another person hold the point on a mark on the standard scale, while you scratch a corresponding mark through the paraffin on the brass scale.

6. With a small wooden paddle, apply acid on the metal where the paraffin has been scratched off. The strength of the acid should be 1 part of nitric acid to 2 parts of water.

7. Watch the etching process to ascertain when the required depth is reached. Acid works sidewise on the surface as well as downward into the metal, so the action should be stopped before the lines become too broad.

8. Use a standard metric scale, and graduate the other side of the brass scale into millimeters for ten centimeters.

9. With a sharp steel point, print the numbers similar to those on standard scales in shape, size, and position. This must be done on each scale to suit the graduation.

10. Warm the metal, and remove the paraffin. Cut off the ends, and file them square to make the end margins equal. Polish the scale.

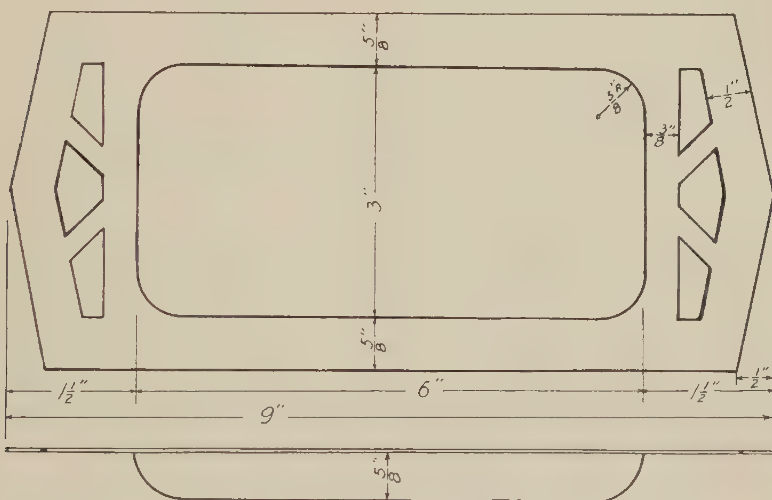
QUESTIONS

1. What is the difference between 4 in. and 10 cm., measured in inches?
2. How many centimeters in 1 ft.?
3. How many inches in 1 meter? in 1 decimeter?
4. What would be involved if our industries changed from one system of measure to another?

Problem 20

OBLONG DESK TRAY

Subject and Uses: A copper tray is not only a useful desk receptacle for the many items such as paper clips, rubber bands, pencils, and the like, but if artistically made it also is ornamental. This tray is formed from a piece of oblong, flat copper. If this copper is too hard, it should be annealed, by heating red-hot in a gas flame, and then plunging it into cold water, after which it should be dried in sawdust. The dish of the tray is shaped with a raising hammer over a hardwood block, about 1 in. thick, which is held in a vise. The metal is held on the block so that the line indicating the edge is held on the block, with the line indicating the edge of the dished area directly over the edge of a slight recess that has been cut in the block. With light hammer blows along the inside of the



DETAIL OF OBLONG DESK TRAY

line on the metal, the copper is driven down against the curve in the block. The line is followed closely the first time around, and the metal is moved along and turned on the block, as the operation continues. At each turn, the peening is a little inside the previous line of blows. The recess in the block is then cut deeper, and is shaped to make the curve desired for the bottom of the tray. As there is a tendency for the oblong tray to curve up at the ends during the stretching process, frequent straightening is necessary to preserve shape. Where two surfaces at right angles require stretching, hammering over both must be evenly distributed. Careful study of the art of hammering will reveal great possibilities

in fashioning artistic copper articles. The pierced design in the end borders is lightly outlined with a scriber, and is cut out with a metal saw. A saw blade is put through a hole drilled just inside the line of each area, and the metal is cut out leaving 1/64 in. for finishing.

In working sheet copper, exercise care against nicking, scratching, sharp bending, or excessive stretching so no cracks will develop, as the metal becomes thinner. It is well to remember that much hammering makes the metal hard and brittle. Annealing restores its original softness.

Object of Lesson: To study the action of plastic metal in the process of stretching; forming and piercing an oblong tray.

Tools and Equipment: Vise; block of hard wood; raising hammer; metal saw; snips; file.

Materials Required: One piece of No. 22 sheet copper, 4½ by 9¼ in.

Procedure:

1. Draw an outline of the tray on sheet copper cut to the required size.
2. Grip the hardwood block in a vise, and cut away a shallow portion about ¼ in. deep. (See Problem 9.)
3. Place the sheet copper on the block, and hammer a recess inside of the line, as previously described.
4. Cut the recess in the wood block deeper and curved to conform accurately to the shape required for the bottom of the tray.
5. Keep the tray straight, and finish the recess smoothly by careful hammering.
6. Cut the outside edges to conform to the drawing, and finish off with a file.
7. Lay out the design on the end borders, saw out, and finish with a file.
8. Finish the tray by filing and polishing over all.
9. The tray may be given a dark color by dipping it into a porcelain dish containing a boiling solution of 1 oz. liver of sulphur and 1 qt. of water. Rinse the tray thoroughly.

QUESTIONS

1. How long has copper been put to useful purposes?
2. For what reasons were kettles formerly made of copper?
3. For what purposes is copper used in preference to other metals?
4. In hammering an oblong tray, why do the ends tend to curve up?
5. Would it be desirable to enrich the border with an etched design?

Problem 21

ROUND COPPER BOWL

Subject and Uses: The round copper bowl is a general type for a great number of problems that call for skill in the art of stretching metal. The bowl may be shaped to other outlines than that shown in the

drawing with some slight modification of contour, size, and work. The problem affords a fine opportunity for the fascinating study of the ductility of metal.

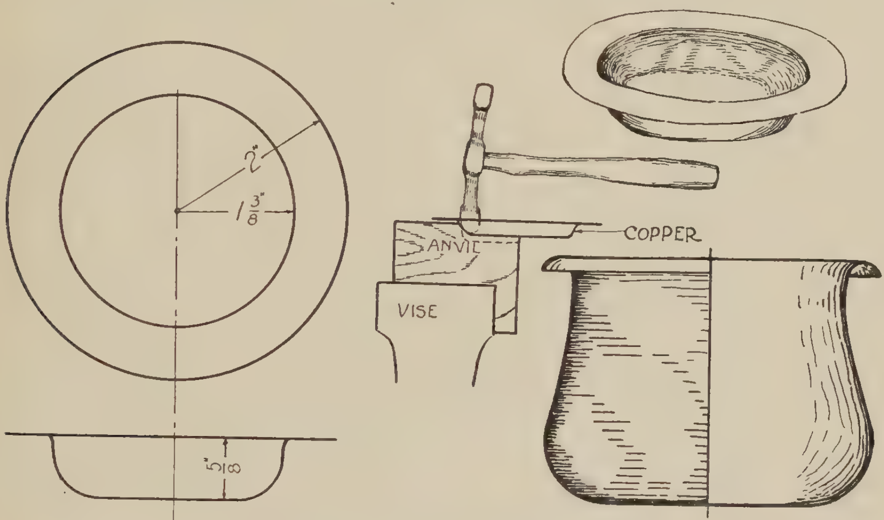
Object of Lesson: Experience in metal stretching; shaping, annealing, and finishing copper.

Tools and Equipment: Vise; wooden anvil; raising hammer; snips; tongs; gas flame; file.

Materials Required: One piece of No. 20 sheet copper, 4 by 4 in.

Procedure:

1. Obtain a piece of No. 20 soft sheet copper, 4 by 4 in.
2. Draw diagonals, and center-punch very lightly.



DETAIL OF ROUND COPPER BOWL

3. Draw two circles, one with a 2-in. radius, the other with a 1⅜-in. radius.

4. With snips, cut the metal to the outer circle. Anneal the metal if necessary.

5. Grip a piece of 1-in. oak in a vise, with the edge grain up, and rasp out a recess ¼ in. deep, and about 1½ in. long. (See drawing.)

6. Place the sheet of copper flat on the wooden anvil so that the inner circle is over the recess and the outer rim rests on the elevated part of the anvil. Start hammering the metal just inside the inner-circle line.

7. Hold the metal and move along with the left hand, while the right hand does the hammering, so that this hammering and turning will form a circle on the copper just inside the inner-circle line.

8. Similarly go a second round, striking just inside the first round.

Continue in this manner until the first stage of the stretching process is completed.

9. Rasp the recess in the wooden anvil a little deeper, rounding the concave to the contour desired for the profile of the bowl.

10. Resume the stretching process; beat the metal down to the increased depth, and hammer out the bottom surface to gain the extra area of metal required.

11. The increased hardness and internal stress resulting from the repeated stretching, may be relieved by annealing the metal. Heat the metal to red heat, and plunge it into cold water.

12. Continue beating the bowl toward the desired depth and shape to symmetrical form. File the edges and finish to uniform surface hammer marks.

QUESTIONS

1. Why should hammer blows be light?
2. Why should sharp hammer marks and depressions be avoided?
3. During the beating process, why should the work be prevented from twisting and warping?
4. May cracks in the work be prevented by annealing and by avoiding sharp bends and dents in the surface?
5. Is the greenish color given to the copper by fumes of spirits of ammonia, desirable in this bowl?

Problem 22
PANCAKE TURNER

Subject and Uses: In making this utensil, the two points that require special attention are: (1) the blade end of the shank and (2) the handle end of the shank. The lower end of the shank is hammered flat and is riveted to the blade. The two rivets should not be set too closely together, and the holes for them should not be so large as to weaken the flattened shank. The holes are countersunk slightly, on top of the blade, for flathead rivets. The tapered end of the shank is driven straight into the handle far enough to fix it solidly without cracking the handle.

Object of Lesson: Turning handle; flattening; drilling; riveting; ferruling.

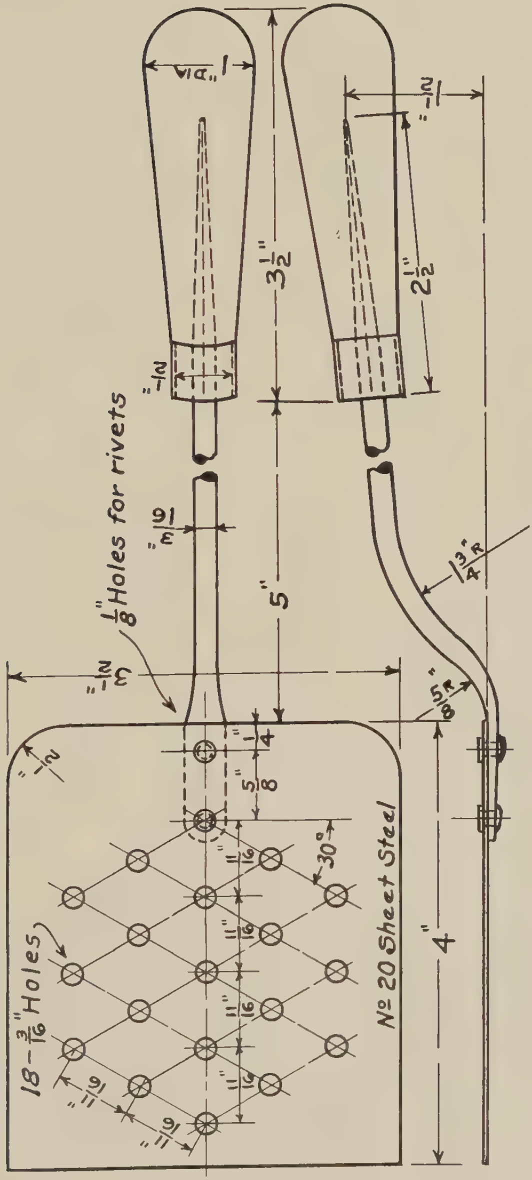
Tools and Equipment: Riveting hammer; breast drill; file.

Materials Required: One piece of No. 20 bright sheet steel, 3½ by 4 in.; 1 piece of No. 8 steel wire, 8 in. long; 1 piece of maple wood, 1⅛ by 1⅛ by 4 in.; one ½-in. ferrule; 2 rivets, ⅛ by ¼ in.

Procedure:

1. Cut the blade to size. File the edges and corners round and smooth. Locate and drill holes for the perforations and the rivets.

2. Hammer one end of the shank fairly flat so it tapers to the thickness of 1/16 in. at the end, and drill the two rivet holes.



DETAIL OF PANCAKE TURNER

3. File the other end to 1½-in. taper of diamond cross section.

4. Fasten the shank to the underside of the blade with 2 rivets, and bend the shank to the required curve.

5. Turn the handle in a lathe. Try to shape it so that it will make a neat, convenient grip. Also in the lathe, turn down the smaller end of the handle to fit the ferrule. The handle may also be whittled out with a knife, after which it must be finished with a file and sandpaper.

6. Drill a small hole into the end of the handle, and drive the shank into place; grip the shank in a vise, and drive the handle on with a mallet.

QUESTIONS

1. Why is the shank fastened to the underside of the blade?
2. How does the spacing of the rivets affect the strength of the joint?
3. Why are pancake turners not made of brass?
4. Are rusty utensils dangerous to health?

Problem 23
GARDEN TROWEL

Subject and Uses: In planning a tool or utensil, the design should be worked out to make the implement most useful in its particular field or place. It should be strong, stripped of all unnecessary trimming, and light as possible consistent with the work it has to do. The handle of a garden trowel should be shaped to fit the hand comfortably. The blade is oval in shape, pointed, and curved, a sort of combination of trowel, shovel, and spade. The shank is riveted to the blade with two rivets, spaced 1 in. apart. The size of the rivet is dependent on the width of the flat part of the shank, because a rivet that is too large will naturally weaken the cross section of the shank at the rivet holes. The upper end of the shank is tapered and driven into the handle.

Object of Lesson: Laying out blade; shaping shank; modeling handle.

Tools and Equipment: Breast drill; riveting hammer; snips; rasp; file.

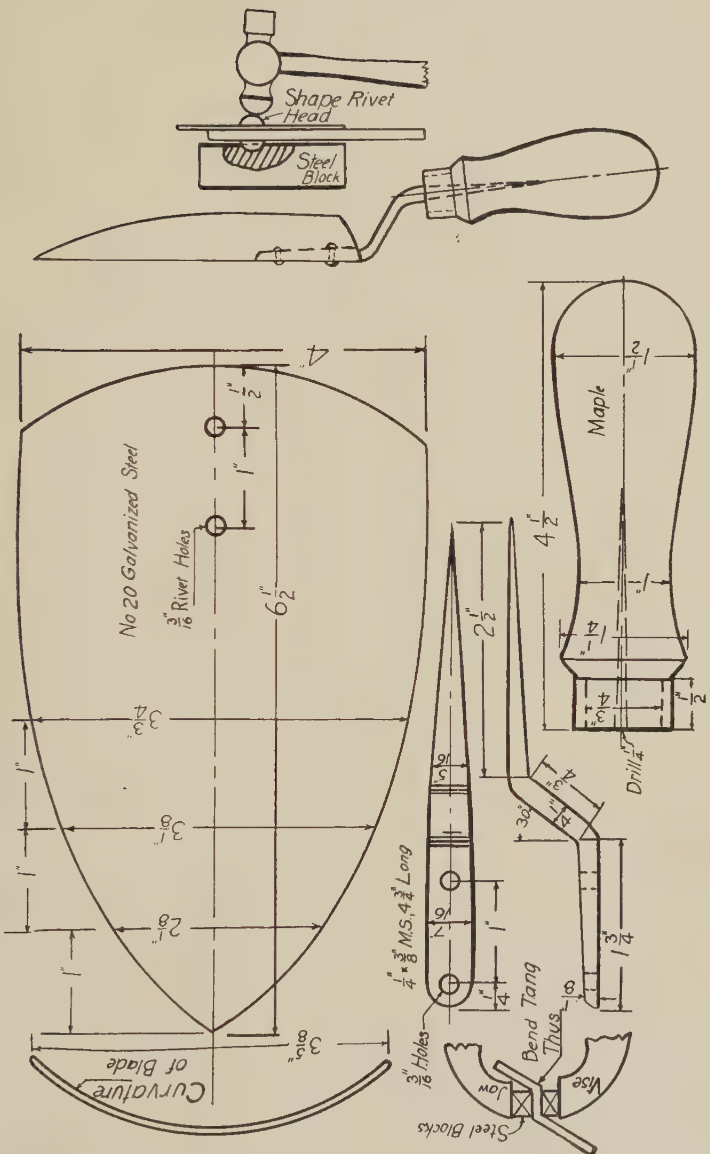
Materials Required: One piece of No. 18 galvanized iron, 4 by 6½ in.; 1 piece of flat iron, 3/16 by ⅜ by 4½ in.; 1 piece of maple wood, 1½ in. square, 5 in. long; 1 piece of ½-in. gas pipe, ½ in. long, or 1 piece of ¾-in. brass tubing, ½ in. long.

Procedure:

1. On section paper, lay out, from coordinate axes, the curve for half of the blade.

2. Fold the paper on the long axis, and cut out the pattern for the blade.

3. Lay the pattern on the metal, draw the exact outline, and cut the blade to shape.



DETAIL OF GARDEN TROWEL

4. File the edges smooth, and sharpen the pointed end of the blade.

5. Make the shank by rounding one end and drilling two holes through it, 1 in. apart. Also, drill the holes through the blade.

6. Hammer and file the upper end of the shank to a taper, 2½ in. long.

7. Grip the shank in a vise, and bend it to shape, as shown in the drawing.

8. Make the handle by turning or by shaping it with a drawknife, rasp, file and sandpaper.

9. From a ½-in. gas pipe, saw a ferrule ½ in. long, and file it smooth.

10. On a lathe, or with a pocketknife, cut down the small end of the handle until it is just a little larger than the inside diameter of the ferrule. Now press the ferrule on the handle between the jaws of a vise. Bore a straight small hole in the handle to lead in the shank.

11. Countersink the holes in the shank slightly, and rivet the blade and the shank securely together.

12. Drive the handle on the shank with a mallet, and polish all parts to a smooth finish. Give the handle two coats of oil.

QUESTIONS

1. In working the shank into the required shape, would it be economical to heat the metal?
2. On what kind of work are cold rivets used?
3. Where should hot rivets be used?
4. What is the advantage in heading a rivet while red-hot?
5. By what method are so many articles pressed into shape, cold?

Problem 24
SCREW DRIVER

Subject and Uses: Unusual strain on a very small area of the blade frequently causes a screw driver to bend or break. The essentials for a good screw driver are steel of good quality, and a blade ground to correct shape and properly tempered. A screw-driver bit is tempered as follows: Heat the lower half of the blade in a clean fire, to a cherry red. Dip that part which is to be hardened, in clean water. When it stops sizzling, withdraw, and polish one side bright with an emery stick. Watch the colors as they travel down from the hotter part of the steel. When the dark-brown color reaches the end of the bit, drop the blade in water and let it cool.

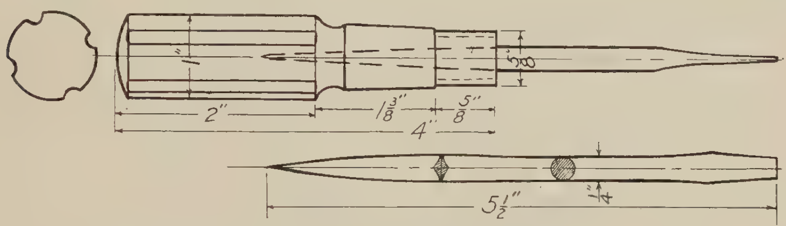
Object of Lesson: Shaping screw driver; hardening; tempering.

Tools and Equipment: Hammer; file; drawknife; emery cloth; fire.

Materials Required: One piece of ¼-in. round or octagonal tool steel, 6 in. long; 1 piece of ⅜-in. gas pipe or ⅝-in. brass tubing, ⅝ in. long; 1 piece of 1¼-in. square maple, 4½ in. long.

Procedure:

1. Forge the blade to shape by heating and hammering the upper end to a taper of diamond cross section, 3 in. long.
2. Forge the lower end into a standard screw-driver bit as shown in the drawing.
3. File the two sides and edges smooth, the end square, and the lower ends of the sides perfectly parallel.



DETAIL OF SCREW DRIVER

4. Saw off a piece of the gas pipe or brass tubing, ¾ in. long and file it to a finished ferrule.
5. Make the handle either by turning and fluting in a lathe, or by shaping it with a drawknife and file.
6. Turn or cut down the end of the handle to a little larger diameter than the inside of the ferrule. Press the ferrule on the handle between the jaws of a vise, leaving a shoulder above the ferrule so that the ferrule is flush with the handle.
7. Harden and temper the blade.
8. Bore a hole into the handle and drive the blade into place.
9. Polish all parts, and apply two coats of shellac on the handle.

QUESTIONS

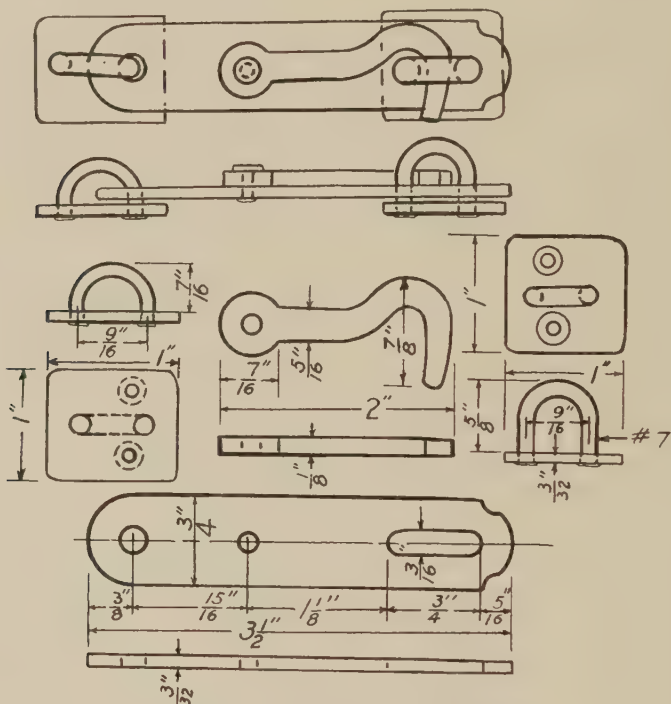
1. Compare the shape of the screw driver with that of the cold chisel and that of the wood chisel.
2. How are these three tools related in hardness?
3. What is a screw-driver bit?
4. Compare the use of a screw driver with that of a wrench.

Problem 25
HASP AND STAPLES

Subject and Uses: It is necessary at times to make metal fittings that harmonize with the surroundings in which they are to be used. A hand-made hasp and staple may be an ugly, cumbersome thing; or it may be fine, inconspicuous, a real ornament, depending on the ingenuity, skill, and patience of the individual making the set.

A hasp carries a hook that swings on a pin. The hook is dropped into

the staple as a fastener when no padlock is used. Staples are fitted tightly, and riveted into the base plates. The screws for the staple fit into countersunk holes and are covered by the hasp, so they cannot be taken out when the hasp is locked in place.



DETAIL OF HASP AND STAPLES

Object of Lesson: Making plate staples; hasp; flat hook.

Tools and Equipment: Breast drill; riveting hammer; hack saw; small chisel; file.

Materials Required: Sheet brass: For hasp, 3/32 by ¾ by 3¾ in.; for hook, ⅛ by 1 by 2 in.; for staples, 3/32 by 1 by 2⅛ in., and No. 7 wire, 3¼ in. long.

Procedure:

1. Begin on the strap by locating, center-punching, and drilling holes. Drill one hole to fit the rivet for the hook. Four 3/16-in. holes are drilled to start the slot, and one 3/16-in. hole for the staple leg.
2. Outline the pattern of the hasp, and cut and file it to dimensions.
3. With a chisel, cut the slot clear, and file it to a finish.
4. Outline the hook, mark and drill the two holes, one in the curve of the hook and one for the rivet, cut it to shape with a saw, and finish with a file.

5. Insert a rivet through the eye in the hook and into the hasp. Tighten rivet just enough so the hook swings up and down freely. Try to keep the rivet head from getting lopsided, for appearance sake.

6. Cut the wire for the staples, one piece 1⅜ in. long, and one piece 1¾ in. long, and bend to shape.

7. File a slight shoulder at the ends of the staples, so the ends will have to be driven into the holes in the plates.

8. Cut the base plates, locate and drill the holes to fit the staples, and countersink the plate holes a little, on the under side.

9. Place the holes for the screws so that the hasp, when fastened, will cover them. Drill and countersink the holes on the top side to fit No. 8 screws.

10. Insert the short staple through the end hole of the hasp, grip it in a vise, and rivet it to the base plate. Also rivet the long staple to its base plate. The riveting must be solid, with heads filling the countersunk holes on the backs of the plates.

11. File all parts smooth, and polish them with oil and emery cloth to a high finish.

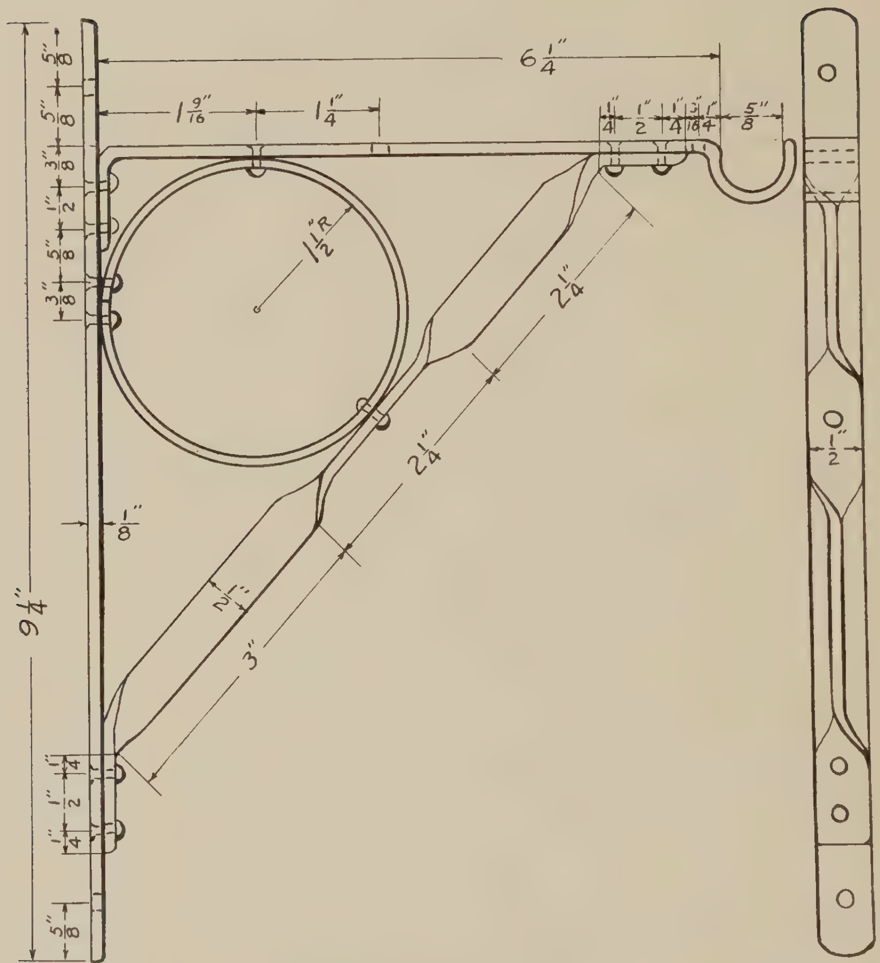
QUESTIONS

1. Copper and zinc, two elements, when melted together, form brass, an alloy. How does brass differ in appearance from copper? From zinc?
2. Copper and tin, two elements, combined form bronze. How does brass differ from bronze, in color, in hardness, in toughness?
3. What metal would you select for the trimmings of a cedar chest?
4. If your choice is one of the following metals, silver, iron, copper, nickel, platinum, tin, steel, brass, gold, bronze, zinc, aluminum, state your reasons for preferring it to each of the others.

Problem 26
LAMP BRACKET

Subject and Uses: This braced bracket may be made to serve as a support for a shelf or for a lantern. The design offers a great variety of possibilities for innovation along the line of embellishment through circles, curves, and twists. It is interesting to analyze how weight is supported by the different members of a bracket and to trace the stresses and strains that are set up in the joints and in the members under different kinds of loads.

Rivets are used for fastening the parts together. Holes for the rivets should fit the shank, and should be countersunk where rivets are to be flush with the surface. If the rivets are to have round heads on both sides of the joint, an allowance must be made in their length so there will be sufficient stock to form a head on the plain end. The heads are rounded by a header, which is a tool with a recess the shape of the



DETAIL OF LAMP BRACKET

desired rivet head. This header is set on the rivet, and struck with a hammer until the desired head is formed. Rivet heads may be flat, conical, hemispherical, or like a spike head or any shape that will help to make the bracket look more trim. In upsetting a rivet, a solid support is required. The rivet is struck squarely in the center to begin with, then light blows follow around until the head assumes a symmetrically rounded shape. Small rivets are upset cold, while on structural steel and boiler work, the rivet is heated red-hot, inserted in the rivet hole, upset, and formed before it has cooled off, the shrinkage, in cooling, drawing the joint together with an enormous force.

Object of Lesson: Making a twisted brace; riveted joints; and ring brace.

Tools and Equipment: Riveting hammer; vise; hack saw; drills; countersink.

Materials Required: One piece of band iron, 1/8 by 1/2 in., 38 1/4 in. long, for back, ring, top, and brace; 10 rivets, 3/16 by 3/8 in.

Procedure:

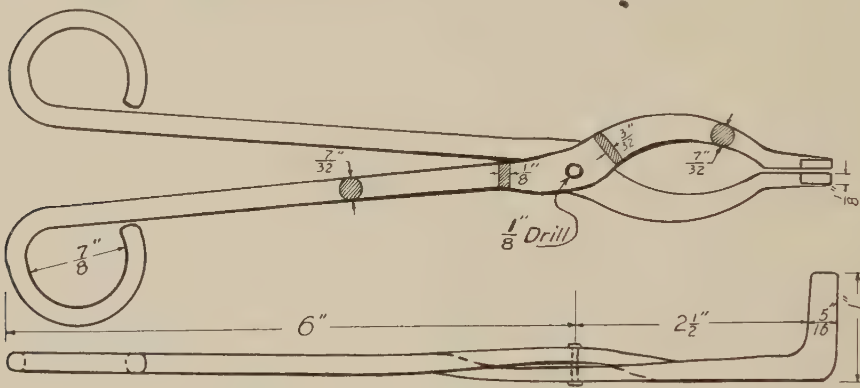
1. Cut the stock to lengths for the four members, as follows: Back, 9 1/2 in.; top, 10 in.; brace, 9 1/2 in.; and ring, 9 in. long.
2. To make the ring, file the ends square and drill rivet holes 3/16 in. from each end, and bend the iron around a pipe.
3. To shape the top, grip the end in a vise between the jaw and a piece of 5/8-in. round stock, and bend a half turn. Then grip the half circle in a vise on the round stock, and bend the top back at a right angle.
4. Drill two rivet holes at the other end of the stock for the top, and bend it down at a right angle, 1 in. from the end. The rivet holes are countersunk on the outside of the top and back pieces.
5. Locate and drill the holes for the wall screws and rivets in the back piece, except the rivet holes for the lower end of the brace.
6. To shape the brace, mark off the distances for twisting, and grip the stock in a vise, 1/2 in. below one of the marks. With a monkey wrench set 1/2 in. above the mark, twist the stock one fourth of a turn. Repeat at each of the four places shown in the drawing.
7. Bend the ends to fit against the top and the back pieces.
8. Locate and drill rivet holes in the ends of the brace and one hole for the ring.
9. Locate and drill rivet holes in the top for the brace and the ring; also the screw holes for fastening a shelf on the bracket, if desired. The top must be at right angles to the back.
10. Locate and drill rivet holes in the ring to meet the holes in the top and the brace.
11. Assemble and rivet the top to the back; the ring to the back; the ring to the top; the brace to the top; and the ring to the brace. Mark, drill, and rivet the brace to the back at the bottom. All rivets have round heads except on the outside of the top and the back.
12. Round off all ends, to a smooth finish. Apply a coat of linseed oil or dull back enamel.

QUESTIONS

1. Why should holes be drilled to fit rivets?
2. What precaution must be taken in riveting, to secure a tight joint?
3. What qualities must metal have to be suitable for a rivet?
4. In starting to upset a rivet, why should the blow strike the rivet end square and in the center?
5. If a 1-in. rivet will support 20 tons, how many pounds will a 1/8-in. rivet support?

Problem 27
ART-METAL TONGS

Subject and Uses: The tongs described in this problem are light, handy, and very useful for holding light objects to be heated, and also for reaching into places that are narrow and inaccessible. They may be made of brass or steel wire. The handles are bent cold, but the areas to be flattened for the hinges and jaws should be heated red-hot in a gas flame before being hammered into shape.



DETAIL OF ART-METAL TONGS

Object of Lesson: Bending curves; heating; shaping, to mate right and left parts.

Tools and Equipment: Vise; anvil; hammer; drill; file; fire.

Material Required: A piece of 7/32-in. hard-drawn, coppered, steel wire, 25 in. long, and a 1/8-in. pin.

Procedure:

1. Make a full-size outline drawing of the tongs.
2. Cut the stock into two equal lengths.
3. To make the handle eye, grip the end of the wire in a vise between the jaw and a piece of 7/8-in. round stock, and give the wire a one-half turn.
4. File the end of the wire round and smooth, and finish bending the handle, as shown in the drawing.
5. Bend the wire at the point of the hinge, so that the pieces mate. Form the arcs for the curves, and bend the ends at a right angle for the jaws. Make one right-hand piece and one left-hand piece.
6. Heat the area for the hinge red-hot, and hammer it quickly to flatten and broaden it.
7. Heat the jaws and hammer them flat. Fit the two so that the parts

come together flat. Bend the two members so as to lie in one plane, except at the hinge crossing.

8. Locate, center-punch, and drill a ⅛-in. hole in one piece for the hinge.

9. Put the two jaws together, and mark the second piece from the first.

10. Center-punch and drill the second piece.

11. File the adjoining faces of the hinge flat, and rivet the pin to form round, full heads, supporting the head in a recess in an iron block.

12. Make the necessary adjustments to the handles and the jaws, and file them smooth.

QUESTIONS

1. Why is the hinge portion flattened? the jaws?
2. Why is the wire curved to shape before it is flattened?
3. Why is the metal heated before hammering?
4. In making common nails, is the wire heated in order to form the heads? Why?
5. Is a piece of a common nail suitable for a rivet?
6. When metal cracks and breaks in being hammered, is that due to crushing blows, or to the property of the metal?

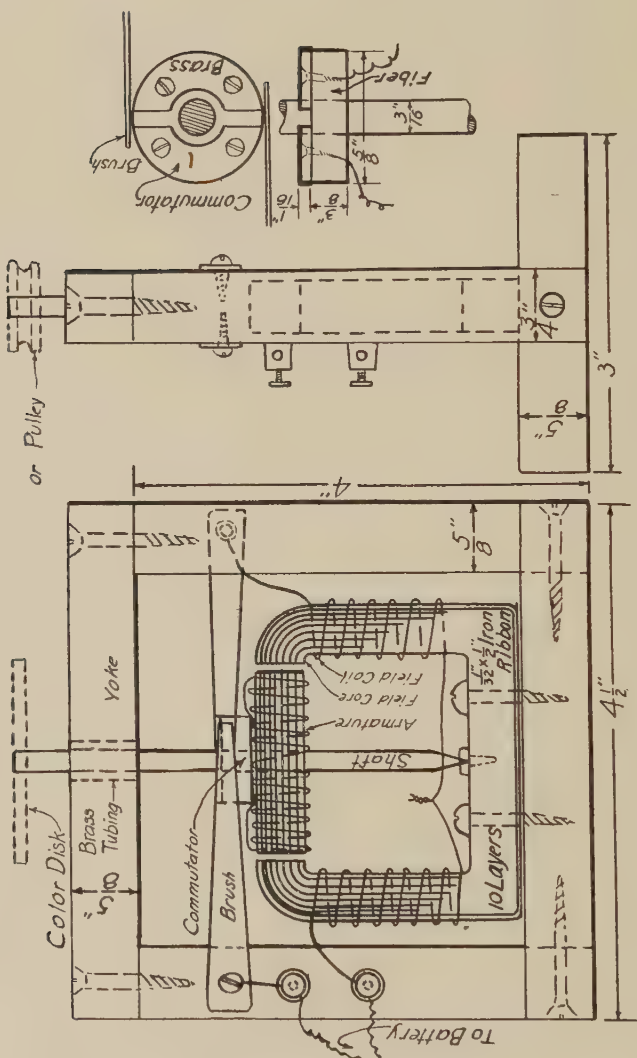
Problem 28
ELECTRIC MOTOR

Subject and Uses: An electrical motor is a device for transforming electric energy into mechanical energy. The parts may be arranged in many different ways, yet the basic principle governing the construction of these motors is virtually the same for all. The three main elements of a motor are: the field magnets, the armature, and the commutator.

Object of Lesson: To wind an electric magnet; to trace an electric circuit; to study the reversal of polarity in a magnet; to make an apparatus that will rotate when an electric current is passed through it.

Tools and Equipment: Woodworking tools; snips; hack saw; breast drill; file.

Materials Required: For the wood frame: 1 piece of ⅝-in. clear-grained wood, 6 in. wide by 4½ in. long; 4 of 1¼-in. No. 8 f.h. brass wood screws. For the field core: 10 pieces of soft, band iron 1/32 by ½ by 7½ in. For the armature: 10 pieces of soft, band iron, 1/32 by ½ by 1¾ in.; 1 copper rivet for the lower armature bearing, 1 piece 3/16-in. brass tubing ⅝ in. long for the upper armature bearing. For the shaft, 3/16-in. steel rod, 4 in. long. For the commutator: ⅝ by ⅜-in. thick circular fiber disc; ⅝ in. No. 16 circular brass disc; 4 of ¼-in. No. 4 f.h. brass wood screws; 2 of 1-in. No. 7 r.h. brass screws, to fasten the field to the base. One piece of No. 24 brass, ½ by 2½ in., for brushes



DETAIL OF ELECTRIC MOTOR

and 2 of ½-in. No. 4 r.h. brass screws; 2 small binding posts for battery connections; No. 26 d.c.c. copper wire.

Procedure:

1. From the ⅝-in. board, saw pieces for the yoke, two uprights, and the base. Plane the boards, make joints, bore for screws, assemble, and finish to dimensions shown in the drawing. Apply two coats of shellac.

2. For the field core, bend 10 pieces of band iron 1/32 by ½ by 7½ in. into a U shape; bend the upper ends in for the poles to meet the ends of the armature, saw off and file the ends square and flat to make a close joint with the armature.

3. Drill three holes through the flat base of the core, one at the center for the copper-rivet bearing for the shaft, the other two ⅝ in. on either side of the center, for fastening the core to the wood base. The base of U core is 2¾ in. wide and the height of the uprights is 2¼ in. outside measure.

4. Wind the uprights with three layers of No. 26 d.c.c. insulated copper wire, all in the same direction.

5. Fasten the field magnet to the base.

6. Make the armature of 10 pieces of soft, band iron, and drill a hole for a press fit on the 3/16-in. shaft, exactly at the center of the armature.

7. Point the shaft at lower end, to fit into the deep center-punch mark in the bearings which is the copper rivet below, and file the upper end to fit into the brass tubing which goes through the yoke.

8. For the commutator, fasten the brass disc to the fiber with four screws. Drill a hole through the center of both for a press fit on the shaft.

9. Remove the brass disc from the fiber, and enlarge the hole in the brass to 5/16 in. Saw the disc into two equal halves, file it smooth, and replace it on the fiber as it was.

10. Mount the armature on the shaft, and wind it with three layers of No. 26 d.c.c. copper wire.

11. Press the commutator into place on the shaft with the brass disc, on under side of fiber, if preferred, and solder one end of the wire to each of the brass segments. Shellac the windings.

12. Bore a hole through the center of the yoke to make a press fit on brass tubing bearing for 3/16-in. armature shaft.

13. File the commutator to balance on the shaft, and let the brass disc project slightly over the edge of the fiber. Mount the shaft in its bearings.

14. Make the 2 brushes of No. 24 brass ½ by 2½ in. Hammer the brass to a springy stiffness, and drill a hole at the end of each brush for a No. 4 by ½-in. r.h. brass screw.

15. Locate the two brushes. Fasten them in place so that they fit against the brass commutator segments in such a way that the brushes change from one segment to the other the instant the unlike poles of the armature and the field come together.

16. Mount the two small binding posts on one of the uprights, as battery connections. Connect one to the brush and the other to one end of the field coil. The second end of the field coil will be connected to the other brush.

17. Trace the current circuit to make sure that all connections are right, as follows: From the first binding post to the first leg of the field; to the second leg of the field; to the first brush; to the first commutator segment; through the armature coil; to the second brush; to the second binding post; to the negative battery terminal; down through the acid to the positive terminal and to the first binding post.

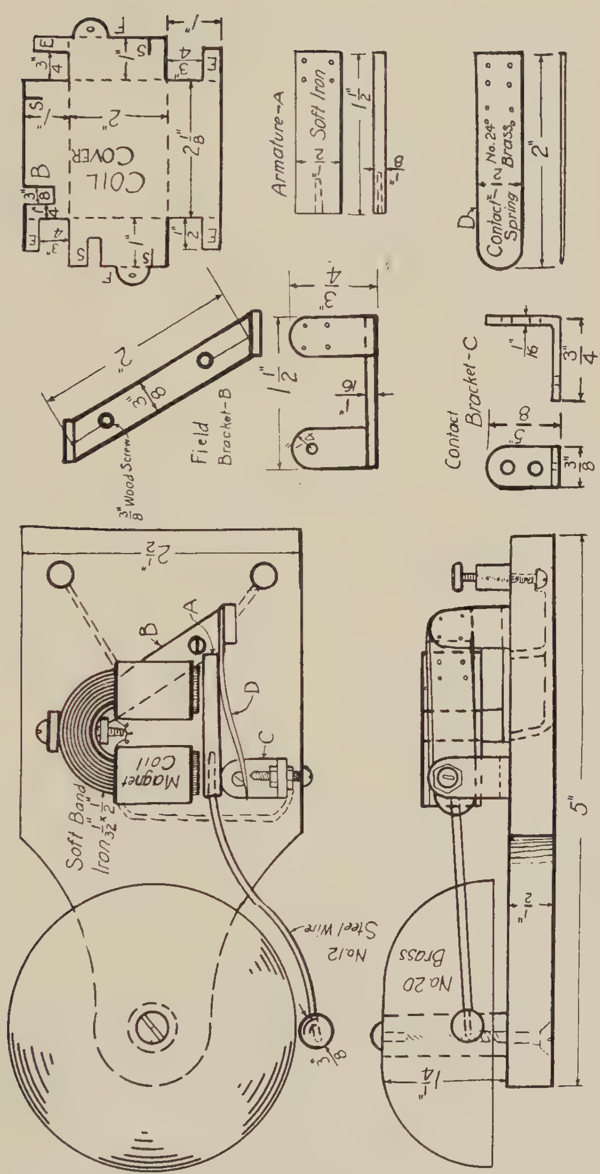
18. Test the motor for speed and power, and make such adjustments as are necessary to make it run smoothly.

QUESTIONS

1. How is the polarity of a magnet determined?
2. How is a permanent magnet made?
3. What is the distinction between a direct and an alternating current?
4. How is the ordinary direct-current armature wound and connected up?
5. How is the commutator made, insulated, and assembled?

Problem 29
ELECTRIC BELL

Subject and Uses: When an obstruction is placed in the path of an electric current, the purpose is to make the current work for us, just as the force of a waterfall is converted into useful energy by placing a mill wheel in its path as an impediment. In the electric bell, the current is made to work to make the hammer vibrate. This is accomplished by making use of the following principle: When a current of electricity is sent through an insulated wire that is wound around a soft-iron rod, the iron becomes a magnet, and the ends of the rod are then called "poles," one a positive pole, and the other a negative pole. While the current flows through the coil around the iron rod, the rod is magnetized, and has power to attract other iron pieces. If the current is shut off, the rod instantly loses that power; but when the current is turned on again, the rod at once becomes magnetized. The electric bell has a wire coil wound on a U-shaped core. A piece of iron called the "armature," is mounted on a flat spring, and so suspended that with the least possible effort it may be vibrated between the poles of a magnet and another point of contact.



DETAIL OF ELECTRIC BELL

The instant the spring hits the contact point, it "makes" a circuit. The current magnetizes the core, which at once draws the armature from the contact point, and "breaks" the circuit. The "break" of the circuit demagnetizes the core, and the spring and the armature swing back to the contact point to "make" another circuit, and so on.

In this way, by the alternations in the make-and-break circuit, a rapid vibration of the armature is set up. A hammer is fastened in the yoke of the armature, and is adjusted so that the head strikes the bell at each make-and-break in the circuit, causing the bell to ring.

Instead of making the magnet core of a solid iron rod, thin band iron is used in a pile of ten layers. This style of core hinders the setting-up of magnetic "eddy" currents in the iron.

Object of Lesson: To make an electric vibrating instrument; to fashion metal to gong shape.

Tools and Equipment: Coping saw; breast drill; vise; snips; hack saw; file; raising hammer.

Materials Required: For the base: 1 piece of clear-grained wood, ½ by 2½ by 5 in. For the magnet core: 10 pieces of 1/32-in. soft, band iron, ½ by 3½ in. For the bracket: 1 piece of iron, 1/16 by ⅜ by 3½ in. long; Four ½-in. f.h. wood screws. For the contact-point bracket: 1 piece of iron 1/16 by ⅜ by 1½ in. long; 2 nuts, to fit on a 1-in. screw. For the armature: 1 piece of soft iron, ⅛ by ½ by 1½ in. long. For the spring: 1 piece of No. 24 brass, ½ by 2¼ in.; 8 slender rivets. For the bell: 1 piece of No. 20 brass, 3 by 3 in. For the hammer: One ⅜-in. brass cube; 3 in. of No. 12 steel wire. For the bell support: 1 piece of ⅜-in. dowel, 1¼ in. long, 1 in. r.h. wood screw at the top, 1¼ in. f.h. wood screw at the bottom, through the base; 1 small bolt to join the core to the bracket, 2 binding posts. For the magnet coil; No. 30 d.c.c. copper wire. For the cover: 1 piece of No. 26 sheet metal, 4¼ by 4¾ in.; two ¼-in. r.h. wood screws.

Procedure:

1. Lay out the base to the shape shown in the drawing. Saw out the base, file, polish, and stain it, and then give it two coats of shellac.

2. Make the magnet core by bending 10 pieces of band iron to a U shape, drill a hole for a bolt through the base of the U, bolt the pieces together, and saw the ends off even.

3. Wind the legs of the U magnet evenly and in the same direction, and wind 5 layers of No. 30 d.c.c. copper wire.

4. Bend the magnet bracket to the required angles in a vise (see drawing) and hammer the leaning brackets edgewise so that they stand up straight. Drill and countersink the holes as required.

5. Shape the gong by hammering, finish it by filing and center drilling, and with 2 screws and a piece of dowel rod, mount it securely and solidly on the base.

6. Drill a hole into the end of the armature, press in the wire for the hammer, and cut the wire to length.

7. Drill a hole in the hammer, file it to a ball shape, press it on the wire, and polish it.

8. Make the flat brass spring by light hammering, cut it to shape, drill it and the armature together for 4 slender rivets, and fasten them together.

9. Drill the spring and the magnet bracket, and rivet them together with 4 rivets.

10. Locate and fasten the bracket to the wood base with two ½-in. f.h. screws.

11. Mount the magnet on the bracket with a small bolt.

12. Bend, file to shape, drill, and locate the contact bracket, and fasten it to the wooden base with screws. Adjust the contact screw by a nut on each side of the bracket. Make the screw pointed.

13. Locate and fasten 2 binding posts to the base.

14. Make wire connections as follows: From the first binding post to the beginning of the first magnet coil; from the end of the first to the beginning of the second magnet coil; from the end of the second coil to the contact point; from the joint of the spring and the magnet bracket to the second binding post.

15. Drill holes for the binding posts, and smaller holes for other contact points where only a thin wire is to be brought up through the block. On the bottom of the base make deep, narrow grooves as beds in which to lead the wires, connect the wires to their terminals and fill the grooves with sealing wax for protection against injury.

16. Make the necessary contact adjustment. Test the bell for ringing efficiency, by attaching the battery terminal wires to the binding posts.

17. To make a metal cover for the coil, lay out, cut, and bend a cardboard pattern, and adjust it to fit, preliminary to cutting and shaping the metal cover. In the drawing for the bell cover, the dotted lines indicate right-angle bends, the opening B is for the vibrating-hammer wire, and the extensions E are bent and inserted through slits S. These extensions are then given a return bend to make the corners of the cover tight, and the ears F are bent out at right angles for fastening the cover to the base with two ¼-in. r.h. screws.

18. Inspect all details for short circuits, for durability, and for neatness in workmanship.

QUESTIONS

1. How is the tone of the bell affected by the way it is fastened?
2. Why must the magnet wire be well insulated?
3. Is it necessary to insulate the magnet core from the bracket? Why?
4. In what way is the "pull" of the cores affected by the number of turns of wire on the coils?
5. Since the two ends of the U magnet core are positive and negative poles, that is, of opposite polarity, how can both attract the armature?

Problem 30
ELECTRIC SOLDERING IRON

Subject and Uses: The danger and inconvenience of the blowtorch for heating soldering irons is done away with by the use of the electric soldering iron. The electric soldering iron retains an even heat which insures better and more satisfactory work than was done with the old-style soldering iron. Here we have another instance where electricity is made to work for us by putting an obstruction in its path. This time, the current heats a coil of steel wire red-hot, which in turn heats the soldering copper. The dimensions for the parts may be changed if this will help to make use of the material on hand.

Object of Lesson: Making coil; testing, fitting, and insulating for an electric heating apparatus.

Tools and Equipment: Vise; file; pipe dies and tap; breast drill; auger bits; brace.

Materials Required: One piece of ½-in. round copper, 5½ in. long; 1 piece of ¼-in. wrought-iron pipe nipple, 4¾ in. long; 1 piece of 1-in. thin brass tubing, 4½ in. long; 1⅛ by 1⅞-in. transite or iron collars with ½-in. bore. For the handle: 1 piece of 7-in. maple wood and a 1-in. ferrule; four ⅜-in. r.h. brass machine screws, and two 1-in. r.h. brass wood screws; 1 piece of No. 28 Cromel "C" wire or Nicrome wire 28 ft. long; 1 sq. ft. asbestos paper, liquid glass (sodium silicate) for cement and small glass beads for insulating wire through handle.

Procedure:

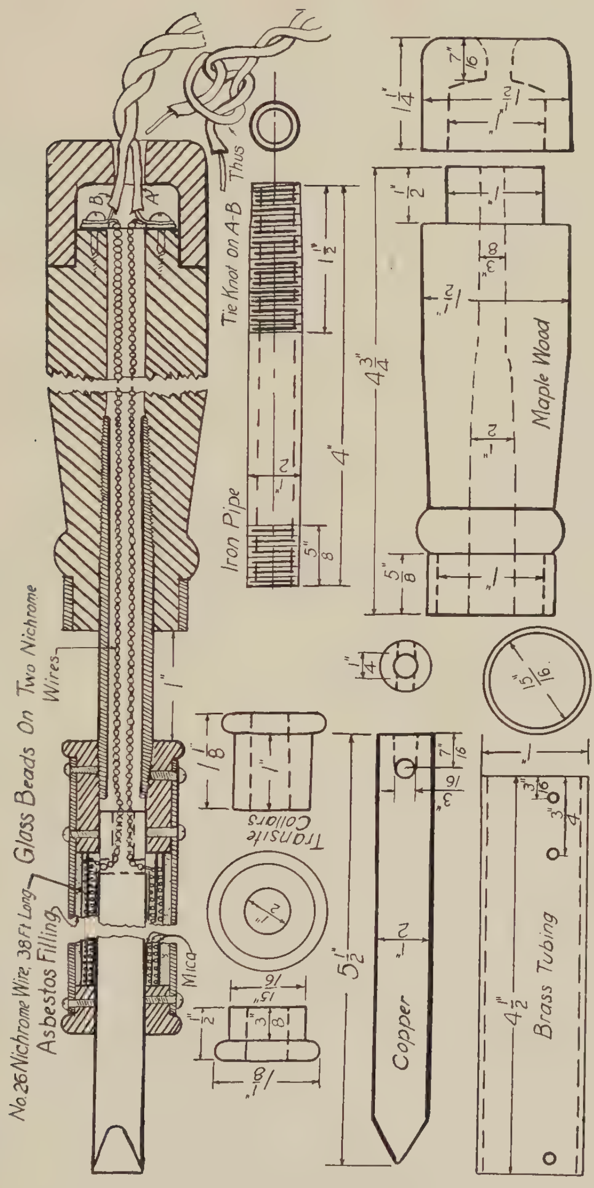
1. File one end of the copper to a four-sided pyramid and the other to a drive fit in the gas pipe.

2. Cut a thread 1½ in. long on each end of the ¼-in. wrought-iron pipe, and drill a ¼-in. hole through the pipe, ⅝ in. from the end that is fitted on the copper.

3. File off all burrs on the pipe ends inside and out.

4. File the 1-in. brass tube to a bright finish, and drill 2 holes 3/16-in. from each end, for No. 6 screws.

5. Turn up the collars, with a shoulder to fit inside and against the end of the brass tubing. Bore a hole in one collar so it may be pressed



DETAIL OF ELECTRIC SOLDERING IRON

on the copper. The hole in the other collar is to be tapped to screw on the pipe so it goes up just above the ¼-in. hole through the pipe.

6. Make a ferrule of 1-in. pipe, ⅝ in. long. File off the sharp edges, and polish it.

7. Turn down the handle end and in a vise, press on the ferrule. Bore out the cap. Turn the other end of the handle to fit snugly into the cap. Turn the cap and the handle together in the lathe to a finish.

8. Bore a hole through the ferrule end of the handle to screw tight on the pipe and a ⅜-in. hole clear through the handle and the cap.

9. Drill holes, and insert 2 binding screws into the end of the handle, under the cap.

10. Set the transite collars in place in the brass tubing, drill and tap them for No. 6–32 r.h. brass screws. Mark them for reassembling, then take them apart.

11. Screw the collar in place on the pipe. Press the copper into the end of the pipe.

12. Determine the space for winding the Nicrome wire coil on the copper, and insulate by cementing down a thin layer of asbestos paper to cover the metal parts.

13. Begin winding the coil by doubling the wire, long enough to reach from the coil, through the hole into the pipe, and up through the handle to the binding post. Twist the wire together, and insulate it by stringing glass beads on the wire, or by cementing asbestos paper throughout the whole length.

14. Screw the handle in place. Fasten the end loop under the screw. Wind the first layer of wire around the copper core. Leave a space 1/32 in. between turns. Cover the wire turns with a thin layer of asbestos paper, cemented down. This must be done for each of the four layers of wire turns. The work of insulation must be done carefully at all points, as it will be subjected to severe tests by heating and handling.

15. Double the end of the wire, and twist it together to reduce the resistance up through the handle. Insulate and insert it through the hole in the pipe and up through the handle to be fastened to the binding screws.

16. Slip the end of the extension cord through the cap, tie a knot as shown in the drawing, and fasten the ends to the binding screws. Fasten the cap in place, and attach the plug to the cord.

17. Slide the brass tubing over the insulated heating coil on the collar.

18. Press the second collar over the copper and into the end of the brass tubing, and with screws fasten the tubing to the two collars.

19. Apply a coat of paint or two coats of shellac to the handle.

20. When ready, connect the soldering iron with city current and give it a practical test, to ascertain if it reaches and maintains the correct soldering heat.

QUESTIONS

1. Why is a specially prepared wire required for heating elements?
2. Would mica serve as an insulator of the heating wire? Why?
3. Why are insulation layers made as thin as possible, between wire turns and the copper?
4. In tracing this heat energy back to its source, how many forms has it passed through? What is the source?

Problem 31

POCKET WRENCH

Subject and Uses: A wrench that will fit nuts located in cramped places, is a very handy tool. A wrench must fit the nut for which it is designed. It must be strong and durable and not bulky. The patterns here suggested have so many standard openings, that they will fit many sizes of nuts and bolts on automobiles and other machinery.

Object of Lesson: Power drilling; sawing; chipping; filing openings to size; shaping curved jaws; casehardening.

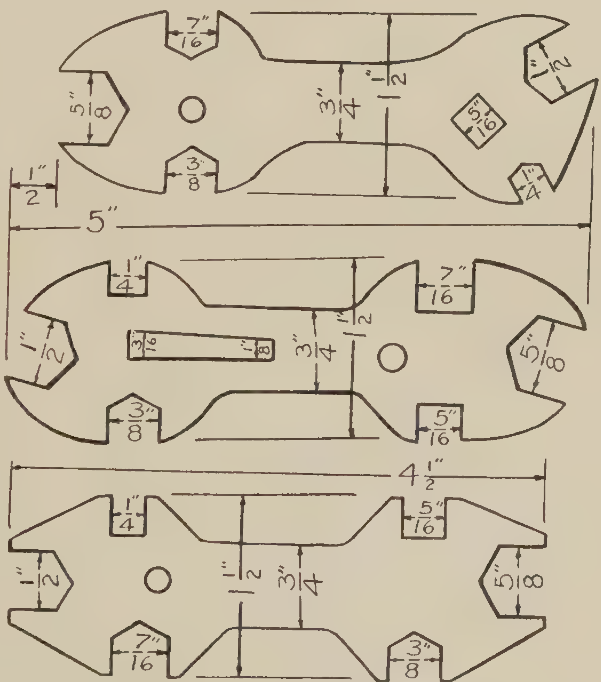
Tools and Equipment: Power drill press; vise; hack saw; cold chisel; hammer; file.

Materials Required: One piece of machine steel, 3/16 by 1½ by 5 in.

Procedure:

1. Saw off the steel, and square to length.

2. Rub a coat of chalk over the face of the stock, spread it evenly, and draw the outline with a scratch awl.



DETAILS OF POCKET WRENCHES

3. Make light center-punch marks on the lines showing the shape of the wrench, to serve as a guide when the lines are rubbed off.

4. Make heavy center-punch marks in the center of the openings, and drill holes to the size required.

5. With a hack saw, make two cuts inside of the line and to the required depth in each opening. Also, make a sloping cut at each end of the handle, on both sides.

6. With a cold chisel, take a shearing cut along the bottom of the openings for the handle, holding the stock in the vise just below the line, and cutting from both sides.

7. File all openings to the required width and depth.

8. File the jaws and the handle to conform to strength and beauty, and round off the edges.

9. Drawfile the faces, smooth and finish the edges to shapely, continuous curves, and polish with oil and emery cloth.

10. Caseharden the openings to prevent wear, by heating to cherry red. Dust the parts to be hardened with powdered potassium ferrocyanide to carbonize the steel. Heat again to bright red and drop into water to cool. Clean and polish.

QUESTIONS

1. Why should the sides of the opening be parallel and square with the face of the wrench?
2. In starting the hack saw on rectangular stock, what precautions are necessary?
3. In chipping with a chisel and a hammer, on what point of the work should the eye be fixed?
4. How should the chisel be held in order to shear off the metal?
5. Why has the file the tendency to travel in an arc?
6. How may the file be guided to move in a straight line?

DETAIL OF DIVIDERS

Problem 32
DIVIDERS

Subject and Uses: This tool is a part of the equipment of the mechanic, engineer and others, and is needed for spacing distances and laying out work. It may be easily made. The joint requires careful construction, since a uniform amount of friction is needed to hold the parts in the place where they are set. The washers and rivets must be strong and solidly united.

Object of Lesson: Making friction rivet joint and taper points.

Tools and Equipment: Hack saw; breast drill; countersink; riveting hammer; file.

Materials Required: For the legs: One piece of machine

steel, 1/16 by ⅝ by 5 in. For the washers: One piece of ⅛-in. machine steel, ⅝ by 1¼ in. For the pin: One piece of ⅛ by ½-in. soft, rivet steel.
Procedure:

1. Cut the stock to ⅝ by 5 in. and locate the points at both ends, 3/32 in. from the corners, diagonally opposite. Connect the points by a line.
2. Saw on the line, cutting the stock into two equal triangular pieces.
3. Locate and center-punch for the hole in the middle and 5/16 in. from the broad end.
4. Draw a semicircle and, on it, make a series of light punch marks.
5. On the stock for the 2 washers, locate the holes, center-punch, draw ½-in. circles, and mark lightly.
6. Drill holes through the legs and washers to make a snug fit for the pin. Countersink one side of each washer.
7. Cut the washers apart, saw off the corners, and file to the circle line.
8. With the pin in place, hold the legs in the vise, and file the edges to shape. Separate the parts.
9. Drawfile all faces to a uniform thickness and to flat, smooth surfaces.
10. Assemble the parts and rivet them together. Upset the ends of the pin so that the riveted ends fill the countersunk sides. Hammer down the riveted ends until there is an even, smooth friction from where the legs are closed, to the wide spread of the dividers.
11. File the ends of the legs to perfect taper points, the faces of the washers flat, the joint round, and all parts smooth. Polish with oil and emery to a perfect finish.
12. Carbonize the points, harden them in oil, and polish bright.

QUESTIONS

1. How may a taper piece be gripped in the vise?
2. How may a finished piece be gripped in the vise and not be marked by the hard jaws?
3. How may a slender piece be heated without burning it?
4. For carbonizing machine steel, what other substance than potassium ferrocyanide may be used?
5. In tempering, what is the difference in the cooling properties of water and oil?

Problem 33
INSIDE CALIPER

Subject and Uses: The inside caliper is used for measuring diameters of holes and the inside dimensions of other spaces. It also is used to set outside calipers to measure a shaft that is being turned to fit a hole. First

set the inside caliper to the exact size, and then set the outside caliper to it. The art of setting the caliper to the exact diameter of a hole is mastered only by the careful mechanic. To take such a measurement, proceed as follows: Hold one of the points of the caliper against one side of the hole, and move the other point back and forth and from side to side against the opposite side of the hole, until the exact center of the diameter is found. The accuracy of the setting depends upon the sensitiveness of one's touch to the least degree of pressure on the caliper point.

DETAILS OF CALIPERS
Inside (left); Hermaphrodite (right).

Object of Lesson: Shaping points on caliper; setting caliper to given dimension.

Tools and Equipment: Vise; breast drill; hack saw; countersink; riveting hammer; file.

Materials Required: For the legs: One piece of machine steel, 1/16 by ¾ by 5 in. For the washers: One piece of machine steel, ⅛ by ⅝ by 1¼ in. For the pin: ⅛-in. round, soft steel, ½ in. long.

Procedure:

1. Saw the stock into two equal pieces. The width of one end should be 3/32 in., the other ⅝ in. and the length 5 in.
2. Locate and center-punch for the hole, 5/16 in. from the wide end and the sides.
3. Draw a semicircle for the end shape, and mark lightly.
4. Lay out, drill, and countersink the washers on one side. Make the holes to fit the pin.
5. Saw the washers apart and shape and file them round.
6. Drill holes in the legs to fit the pin.
7. With the pin inserted, hold the legs together in the vise, and file them to shape.
8. Grip the two points in the vise, ⅛ in. up, and bend them edgewise, 45 deg.
9. File these bent ends to rounded, elliptical, end shapes.
10. Drawfile the faces and edges of the legs and the inner faces of the washers.
11. Assemble the parts and rivet them together so that the rivet heads fill the countersunk holes.

12. Oil the joint and turn it all the way around to ascertain if friction is adequate and uniform. Rivet the joint tighter if necessary.

13. Cut the legs at the joint to conform to the circular shape of the washers and file all parts smooth and to definite square edges. With oil and emery, polish the caliper to a fine finish.

QUESTIONS

1. What takes place in an iron rod when it is being bent?
2. When a rod is bent into a ring, does the length change? Why?
3. A rod of square cross section is bent; what is the shape of the section in the bend?
4. Why does a water pipe buckle when being bent? How may this be prevented?

Problem 34
HERMAPHRODITE CALIPER

Subject and Uses: The two legs of this caliper differ both in shape and length. The shorter is the leg of a divider, and the longer, that of an inside caliper. It is used for laying off distances from a given edge; also for locating centers on stock and for testing centered work. When using this tool, it is essential that it is held in an upright position so that, for a given setting, the line will always be the same distance from the edge. What is true of other calipers is also true of this one. Their use requires precision and very sensitive touch.

Object of Lesson: To make a tight joint; bending; pointing ends.

Tools and Equipment: Vise; breast drill; countersink; riveting hammer; file.

Materials Required: For the legs, 1/16 by ⅝ by 5-in. machine steel; for the washers, 1 piece of ⅛ by ⅝ by 1¼-in. machine steel; for the pin, ⅛-in. round, soft steel, ½ in. long.

Procedure:

1. Get out the 1/16-in. stock, ⅝ by 5 in. Locate the point at the end, 3/32 in. from the corner, and draw a line to the opposite corner.
2. With a hack saw, cut to the line, making two triangular pieces.
3. File the edges straight, and drawfile the faces.
4. Lay out, center-punch, and draw a ½-in. circle, and drill the legs and washers to fit the joint pin.
5. Countersink the washers, and cut them into two equal pieces.
6. Saw off the corners and file the wide ends of the legs and the washers to circular lines.
7. File the narrow leg to taper, and round to a fine point.
8. Grip the other leg on the edges, in a vise, ⅛ in. up from the small end. Bend it edgewise, through an angle of 45 deg., file and finish it to an elliptical shape.

9. Rivet the joint so that the friction is firm and uniform all the way around, and so that the rivet heads fill the countersunk holes.

10. Oil the joint and test it by turning it around; rivet tighter if necessary.

11. File all parts smooth, and square the edges of the legs and the washers. Polish with oil and emery to a fine finish.

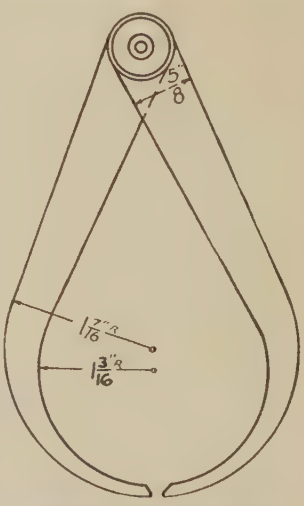
12. Caseharden the point and polish it bright.

QUESTIONS

1. How is the fine adjustment made in a hinge-joint caliper?
2. What advantage has the hinge-joint caliper over the one with screw adjustment?
3. Should calipers ever be subjected to stress? Why?
4. What kind of file should be used for drawfiling? Why?
5. How may a dead-smooth file be cleaned?

Problem 35
OUTSIDE CALIPER

Subject and Uses: This standard tool is made in various sizes and is named according to the largest diameter it will measure: as, 3-in. caliper; 12-in. caliper, etc. The common practice for adjusting the caliper is to hold one of the points against the end of a steel scale, and adjust the other point to the middle of the width of a line on the scale giving the required diameter. Careful study of the method for setting a caliper is very necessary, and indispensable to accurate work. In taking a measurement, the caliper is held so that its plane is perfectly perpendicular to the axis of the work to be measured. The tool must be handled carefully so it will not be jarred from the size to which it is set.



DETAIL OF OUTSIDE CALIPER

Object of Lesson: Bending metal edgewise; shaping caliper.

Tools and Equipment: One piece of pipe, 2½ in. diameter; vise; hack saw; breast drill; countersink; file; riveting hammer.

Materials Required: For the legs, 1/16 by ⅞ by 5½-in. machine steel; for the washers, ⅛ by ¾ by 1¾-in. machine steel; for the pin, ⅛-in. round, soft steel, ½ in. long.

Procedure:

1. On the stock required for the legs, locate a point at each end,

5/32 in. from the corner. Connect them by a diagonal line, and make a series of light punch marks, along the line.

2. With a hack saw, cut the metal into two equal triangular pieces.

3. On the center line and 3/8 in. from the ends, locate, center-punch, draw 5/8-in. circles, and drill holes, through both the legs and the washers, to fit the pin.

4. Countersink the washers, and cut them to make two. Finish by sawing and filing them round.

5. Hold the legs together in a vise, and file the edges straight so that one end of each is 1/8 in. and the other 5/8 in. wide.

6. To curve the legs, put a piece of 2½-in. pipe, horizontally in the vise. Grip the small end of the leg edgewise between the pipe and the jaw, and hammer the leg so that it curves edgewise over the pipe, a quarter turn. Buckling is overcome by pressing the leg flat in the vise.

7. Make the legs alike in shape; file the edges smooth, and the faces flat.

8. Rivet the parts together, and round off the tops of the legs even with the washers.

9. Oil the joint, work it, and rivet tighter if necessary.

10. Adjust the caliper points, and file them to an elliptical shape. The direction of the file should be kept perpendicular to the plane of the caliper.

11. File all edges and faces square and smooth.

12. Polish all over with oil and emery cloth to a fine finish.

QUESTIONS

1. What size cylinder can be measured by this caliper?
2. How must the points be shaped to measure different diameters?
3. What shape of caliper is used for measuring the diameter of threads? for root of threads?
4. What is a vernier caliper? a micrometer caliper?

Problem 36
COMBINATION CALIPER

Subject and Uses: The combination caliper is so constructed that when the end having the inside caliper is set to the size of a hole, the other end having the outside caliper is automatically set to the size of a shaft that will fit that hole. The legs are made exactly alike, and if the tool is intended to be of practical value, it must first of all conform to the two following requirements: (1) A straight line drawn from the points of contact must pass through the exact center of the pin; (2) the distance from the points of contact to the center of the pin must be exactly equal.

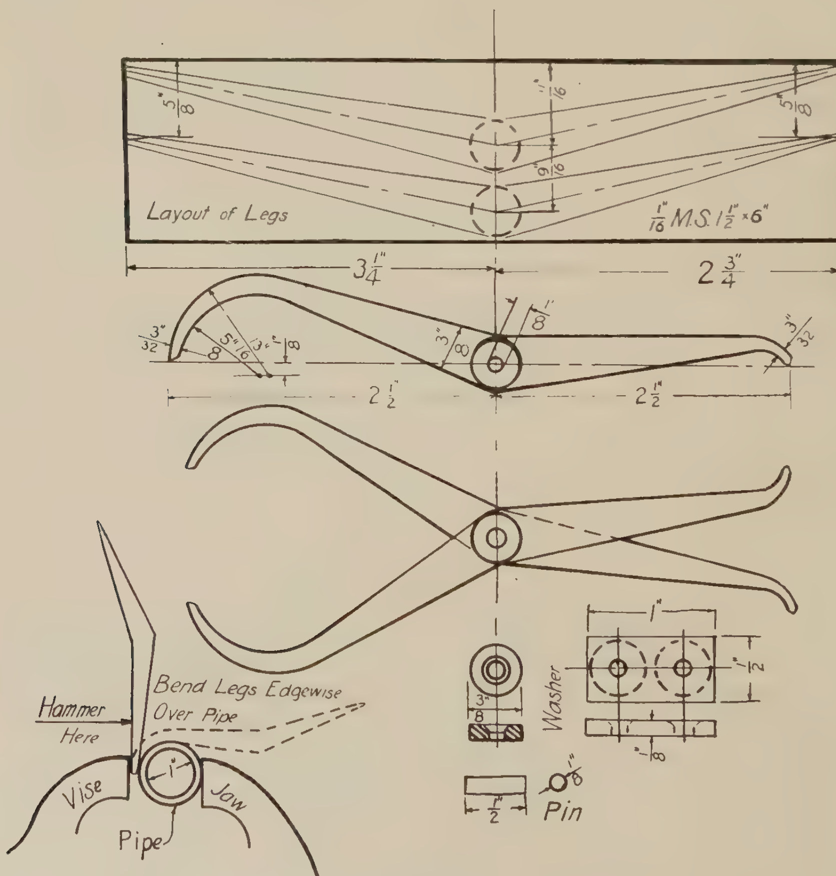
Object of Lesson: Bending metal to dimensions, edgewise, into complex shapes.

Tools and Equipment: Vise; 1-in. pipe; breast drill; countersink; file; riveting hammer; hack saw.

Materials Required: For the legs, 1/16 by 1½ by 6-in. machine steel; for the washers, ⅛ by ½ by 1-in. machine steel; for the pin, ⅛-in. round, soft steel, ½ in. long.

Procedure:

1. Make a full-size pattern of one leg by drawing on stiff paper and cutting it out to the exact shape. (See drawing.)
2. Lay out the two legs on metal, and saw the metal into two pieces.
3. Put the two legs together; saw and file them to the approximate shape.



DETAIL OF COMBINATION CALIPER

4. Bend the outside-caliper legs edgewise over a 1-in. pipe in the vise, to the required shape. Grip end of inside-caliper leg, 1/8 in. up, in the vise and bend edgewise, 60 deg. in the same direction as the point on the other end of the leg.

5. Locate and center-punch the holes for the pin, in line with the points of contact, and halfway between them.

6. Lay out, center-punch, and draw two 3/8-in. circles and drill the washers.

7. Drill the legs, and countersink the washers.

8. Saw the washers to shape and file them round.

9. Flatten the legs by pressing them in the vise, drawfile the faces, and file the edges square.

10. Assemble the caliper and rivet the joint to the required amount of friction.

11. Oil the joint; test it for uniform friction; finish riveting; file the tool smooth.

12. Test the points of contact of the inside and the outside caliper to see that they correspond accurately. Make adjustments. Polish with oil and emery to a perfect finish.

QUESTIONS

1. Does oiling the joint affect the amount of friction? How?
2. How does the area of the rubbing surfaces affect friction?
3. Why does a revolving shafting become heated when not oiled?
4. Why are ball bearings so popular?
5. Does friction help or hinder us in walking? ice skating? roller skating?

Problem 37

GAUGE FOR DRILL POINTS

Subject and Uses: To grind a drill properly, it must be held against an emery wheel at a right angle, and so that the lips will be of equal length and have the proper amount of clearance. With the aid of this grinding gauge, the task of giving the drill point the proper pitch is much facilitated. The gauge is held against the side of the drill to measure the length of the lip and to get the proper angle. The angle of the gauge is 121 deg. which is the standard angle for the lips of a drill. The blade is graduated to make it easier to compare the lengths of the lips.

Object of Lesson: Making standard angle gauge.

Tools and Equipment: Protractor; trammel points; bevel; scale; hack saw; vise; file.

Materials Required: For Figure 1, 1/16 by 1½ by 2¾-in. machine steel; for Figure 2, 1/16 by 2 by 3¾-in. machine steel; 1 piece No. 24 sheet brass, 9/16 by 1 in.

Procedure:

1. Make a full-size drawing on stiff paper. Set a bevel to 121 deg. by the protractor, and transfer the angle to the drawing; then cut out the drawing to make a pattern.
2. Paste this pattern to the metal and saw the metal to shape.
3. Test with the bevel; file the edges to the required angles, straight and square.
4. Drawfile the faces and polish them smooth.
5. Heat the metal enough to melt paraffin and cover one face with a thin, even coat.
6. Graduate the short side into sixteenths of an inch. Begin at the angle, using a 5-ft. trammel and a steel scale, in line with the edge of the short face of the gauge. Both should be clamped to a table, 4½ ft. apart.
7. With one trammel point held on a scale mark, adjust the other point exactly to start at the angle, and making lines through the paraffin to correspond in length with those on the scale.
8. With a small wooden paddle, apply diluted hydrochloric acid on the marks, and let the acid eat into the metal to the required depth.
9. Wash off the acid, and heat the metal to remove the paraffin.
10. Polish the gauge with oil and emery to a perfect finish (Fig. 2).

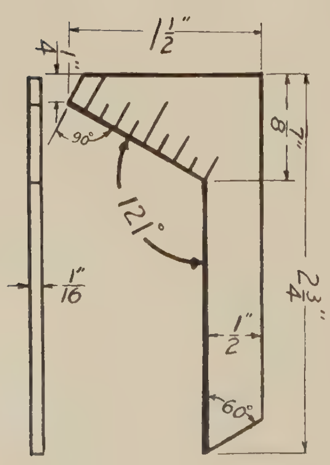


Fig. 1

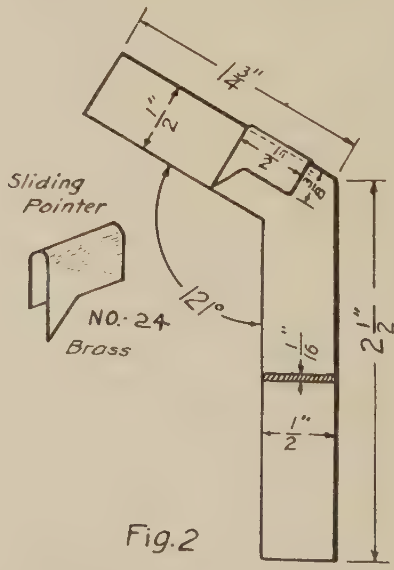


Fig. 2

DETAIL OF GAUGE

11. In making the gauge shown in Figure 2, follow the directions given for Figure 1.

12. The sliding pointer is cut and bent to the shape shown in the drawing, and is filed accurately to dimensions with the edges square and exact.

QUESTIONS

1. Is it desirable to graduate this gauge on both sides? Why?
2. Might a trammel be improvised from two darning needles and a wooden beam? How?
3. Why should the lips of a drill be of equal length?
4. What is the dead center of a drill?
5. What is the shank? The flutes?

Problem 38

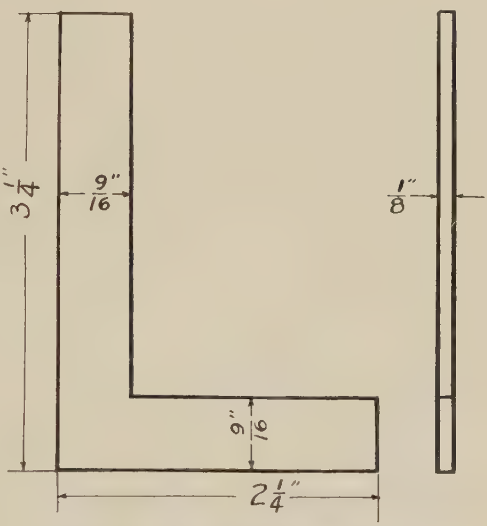
POCKET SQUARE

Subject and Uses: In construction work, the 90-deg. angle is met with so often that a tool is made with blade and tongue fixed at that angle, for checking the exactness of rectangular work. This tool is called a "square." The size of the model described here makes it desirable to make it out of a single piece of stock. The thickness of the material is not very important. However, to make it light in weight, the thickness is held to ⅛ in.

Object of Lesson: Filing exact external and internal right angles.

Tools and Equipment: Standard square; hack saw; file; vise.

Materials Required: Machine steel, ⅛ by 2⅜ by 3⅜ in.



DETAIL OF POCKET SQUARE

Procedure:

1. Select the two best edges on the stock, and rough-file them square.

2. Chalk one side of the sheet, and with a scriber lay out the square on the metal.

3. With a hack saw, cut to the line, leaving 1/32 in. for filing.

4. Rough-file the inner angle and the ends square.

5. File the surfaces, removing all scale or rust, and drawfile to a smooth surface.

6. Using a fine file, go over the sides and edges. Test with a standard square.

7. Drawfile the sides lightly, leaving the edges sharp and square. Test again with another square, but this time use two strips of tissue paper between squares. Test for equal friction.

8. Polish the square with fine emery and oil.

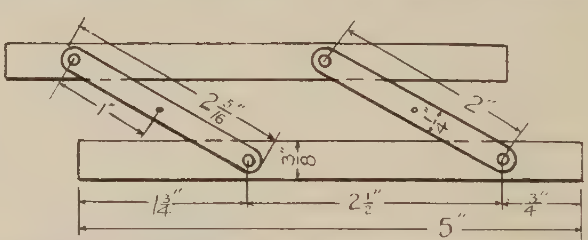
QUESTIONS

1. Why is drawfiling done on this job? What grade of file is used?
2. Are the sides parallel when external and internal angles are square?
3. Why should strips of tissue paper be far apart, in testing the square?
4. How should a square be held when testing an object for squareness?

Problem 39

PARALLEL AND CENTERING RULER

Subject and Uses: Most work can be made easy by using the right tool for the job in hand. Drawing a series of parallel lines is quickly done with a parallel rule. The construction of this instrument is relatively easy, but requires exact workmanship. The pieces of each of the two pairs of bars are made alike. Four rivets fasten these two pairs together in parallel positions. The holes for the rivets are countersunk almost half way through the metal, to make room for the rivet ends which are filed flush with the surface.



DETAIL OF PARALLEL AND CENTERING RULER

Object of Lesson: Making equal parts to move in parallel pairs.

Tools and Equipment: Hack saw; breast drill; countersink; riveting hammer; file.

Materials Required: For the rulers and strips, 1/16 by 1¼ by 5⅛-in., machine steel; for the rivets, one 6d nail.

Procedure:

1. Saw the metal into three strips, two to finish ⅜ in. wide, and one ¼ in. wide.

2. Saw the ¼-in. strip into two equal lengths.

3. On the center line, locate and center-punch for three holes, one in the center and one near each end.

4. Drill the center hole 1/32 in., and drill the holes at the ends to fit the rivets. Get them exactly in place by inserting the pin through the center and letting the end hole of one serve as a template for the other by swinging it on the pin.

5. On the center line of the rulers, locate, center-punch, and drill holes to fit the rivets.

6. Countersink both rulers and strips for the rivet heads.

7. On the four pieces, drawfile the faces, and file the pieces to the required widths. Be careful to make the edges straight and parallel.

8. File the ends of the rulers square and those of the short strips semicircular.

9. Rivet the parts together. Hammer the rivets lightly to form the heads, but do not bend the stem.

10. Test the instrument for adequate friction to stay where it is set, and for folding together perfectly.

11. File all parts smooth, and polish with oil and emery to a superb finish.

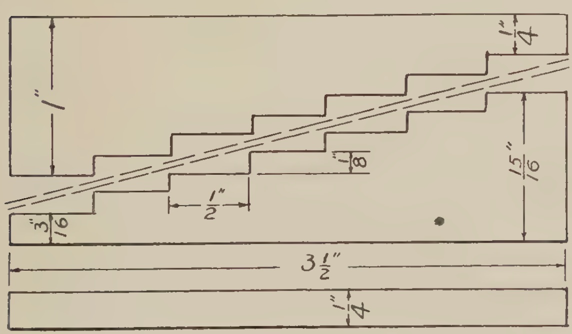
QUESTIONS

1. What is the advantage in working pieces together?
2. Why is one strip used as a template for another?
3. Does that method of drilling put the three holes on a straight line?
4. What is a jig? Why is it used?

Problem 40

STANDARD SIZING BLOCKS

Subject and Uses: A mechanic's kit of tools, to be complete, must include standard sizing blocks. They are time savers in setting calipers and other tools to accurate size in producing work to standard measurements. Some jobs on the planer require the cutting tool to be set at a definite distance from the table. These blocks will be found very convenient in making such adjustments. Also, in setting lathe tools or milling cutters they assure exact sizing.



DETAIL OF STANDARD SIZING BLOCKS

While the successive steps on the blocks increase in height by ⅛ in., sizes that vary by sixteenths can be obtained by using the two blocks together. The sizes that may

be obtained vary from 3/16 in. up to 1 15/16 in. One block contains the sizes from 3/16 in. upward, in ⅛-in. steps, to 15/16 in., the other is similarly made in steps of ¼ in. to 1 in. inclusive. The two blocks are thus used separately for sizes less than 1 in., and together for sizes over 1 in.

Object of Lesson: Making standard test blocks; using micrometer caliper.

Tools and Equipment: Hack saw; files; square; micrometer caliper.

Materials Required: Machine steel, ¼ by 1½ by 3⅝ in.

Procedure:

1. Saw off the stock to length and square.
2. Locate a point on each end, ¼ in. from the corner on the first end and diametrically opposite on the second end, 5/16 in. from the corner, and connect the points by a line.
3. Saw the stock into two triangular pieces, one 1/16 in. narrower than the other.
4. Make a full-size drawing of each block on paper, cut it to shape, and paste it on one side of the steel for each block.
5. With a coarse file, shape each block to the approximate size, leaving 1/64 in. for finish on the sides and the ends.
6. File the bases of the triangles straight and perfectly square.
7. Drawfile the faces, the bases, and the ends.
8. File the steps and the risers straight and square with the sides. The steps must be parallel with the base, and the risers must be parallel with the ends, leaving .002 in. for finish. Make exact measurements with a micrometer caliper.
9. Polish all faces with oil and fine emery until each step is within .001 in. of the required standard size.
10. Caseharden the steps and bases, and lap them to exact sizes with an oilstone.

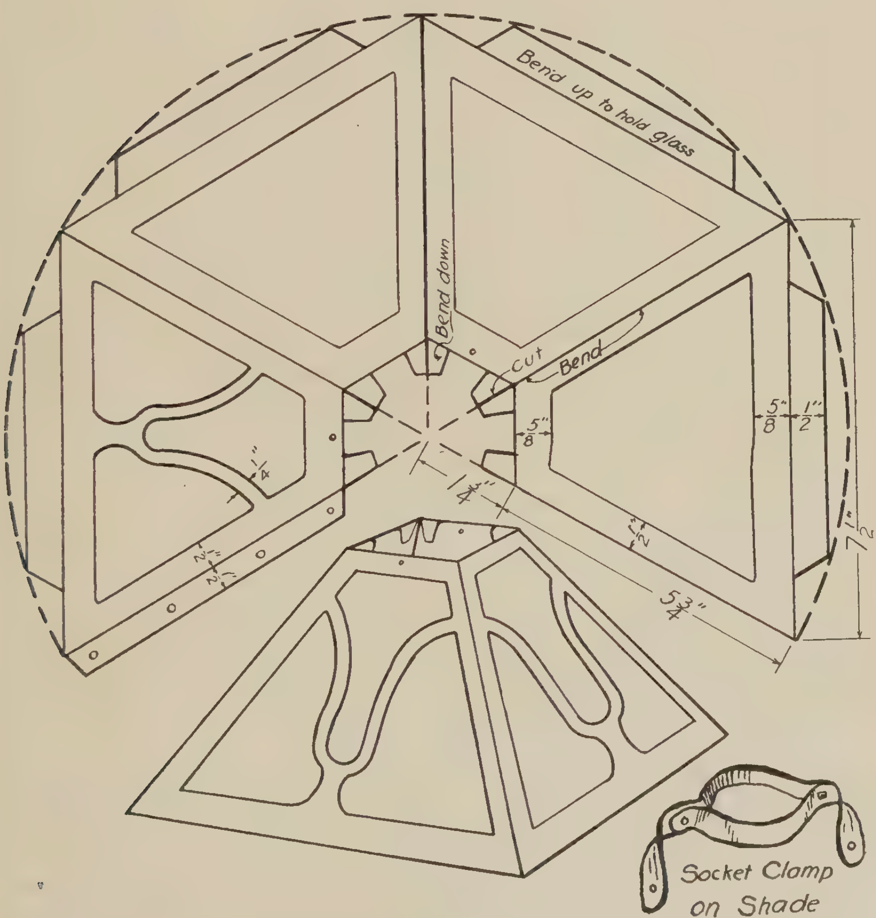
QUESTIONS

1. In the micrometer, of what use is the anvil, the spindle, the sleeve, the thimble, and the ratchet?
2. Why should the ratchet be gripped, rather than the thimble, when measuring by micrometer caliper?
3. In making one turn, the spindle moves endwise .025 in. How many threads per inch has it?
4. Since the thimble is graduated into 25 spaces, and one turn of it is equal to 1/40 in., what part of an inch is one space?
5. How many turns are required to move the spindle 1/10 in.? ⅛ in.? 1/16 in.?
6. Why should the micrometer be held square on the object when measuring it?
7. Why should delicate instruments, of the micrometer class, be handled with great care?

Problem 41

LAMP SHADE

Subject and Uses: A lamp shade should be so designed that the slope of its faces, width and slant height, and cross-rib pattern that bridges the opening for the glass, are in accordance with the design of the lamp. The shade may have four or more faces, and the procedure in laying out the flat surface should be modified accordingly. It is well to make several paper patterns, showing the size and shape of one face of the shade, together with a variety of curved and rectilinear designs for the glass opening. From these a selection can be made. This shade is suitable for either a table lamp or a wall light.



DETAIL OF LAMP SHADE

Object of Lesson: Designing artistic patterns; laying out lamp shades.

Tools and Equipment: Snips; scriber; pliers; three-cornered file; cold chisel; hammer; block of soft iron.

Materials Required: One piece of No. 22 sheet metal, 10½ by 15 in.; brass or copper.

Procedure:

1. Lay out the surface development of the shade on paper, by first drawing one face and extending the slant edges until they meet at a point.
2. Using that point as a center, draw two circles, with the distance to the farther corner as the longer radius, and that to the near corner as the shorter radius.
3. On the larger circle, mark off a number of equal distances and from those points, draw lines to the center.
4. Complete the drawing to the required size, allowing extensions at the top and bottom edges to hold the glass, and one at a side for a lap when riveting the edges together.
5. Cut out the pattern, crease and fold it on the dividing lines. Cut out one face to the exact pattern of the opening for the glass, and fold under the extension for holding the glass.
6. Place the pattern on metal, and with a scriber draw lines accurately to show where the metal is to be bent or cut.
7. With snips, cold chisel, hammer, and a block of soft iron, cut the metal to lines, without distorting it, and file all edges smooth.
8. To bend the shade into the required form, clamp one section after another between two straight pieces of hard wood at the bending lines. Place another similar piece of wood, opposite the side toward which you wish to bend the metal, and strike it with a mallet.
9. Rivet the lap onto the adjoining face, leaving the rivet heads round on the outside and flat on the inside.
10. At the top of the shade, cut clips for holding the upper part of the glass in place.
11. From two pieces of ½-in. strips of metal, make a clamp for holding the shade to the lamp socket. The ends of the strips are fastened by rivets to opposite sides of the shade. The clamp is tightened about the socket by two small screws and nuts.
12. Painted or cathedral glass, previously cut to size, may be used. It is fastened in place by merely bending the clips against it. Forcing the glass should be avoided as it cracks easily.

QUESTIONS

1. Of what is glass made?
2. How is glass blowing performed?
3. How are bottles made?
4. How is window glass made?

Problem 42
READING LAMP

Subject and Uses: In constructing this lamp, convenience, attractiveness, simplicity, and usefulness are taken into consideration. It is an interesting project in art metal, and may be made with but few tools.

The base A is a cross-lap joint, held together by two rivets, spaced diagonally. The ends of the members A are curved in scroll shape, as shown in the drawing. Each of the two uprights B is fastened to the base by two rivets, and is given a half-turn twist in two places. Above the upper twist, the two uprights are swung out into an arc to make room for the lamp shade. As shown in the drawing, they are brought together and riveted in three places. At D, the two pieces are twisted a quarter turn, and are separated to admit the ends of the clamp C between them. A hole is drilled through the four thicknesses of metal for a small bolt with a wing nut, so that the shade may be swung and set to any desired angle. The clamp C surrounds the bulb socket, and supports the shade by connecting strips.

The shade is formed from flat sheet metal by drawing an outer circle with a 7-in. radius, and an inner circle with a 1¾-in. radius. On the outer circle, mark off 6 in. four times, and connect each point with the center by a line; also, join the points on the outer and the inner circles by lines. When cutting off metal for the bulb-socket opening, allow ½-in. radial strips, ¾ in. long, which are to be riveted to clamp C. If it is desired to embellish the lamp with art glass, patterns of different outlines may be designed and cut in paper for light openings in the shade, and the best one selected.

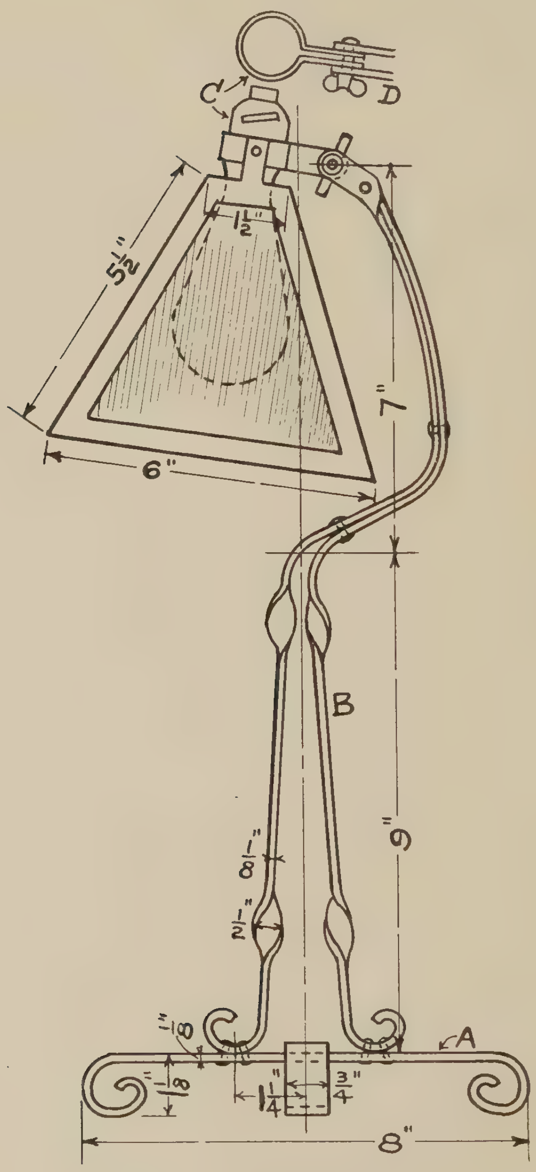
Object of Lesson: Making volute curve; twisting; bending and riveting; laying out, and making shade.

Tools and Equipment: Vise; monkey wrench; hack saw; drill; file; snips; cold chisel; hammer.

Materials Required: For the base, 1 piece of ⅛ by ¾-in. strap iron, 22 in. long; for the upright stem, 1 piece of ⅛ by ½-in. strap iron, 40 in. long; for the clamp, 1 piece of 1/16 by ⅜-in. strap iron or brass, 6 in. long; for the lamp shade, 1 piece No. 22 sheet metal, 9 by 14 in.; 3/16 by ⅜-in. iron, and 1/16 by 3/16-in. copper rivets; a 3/32-in. wing nut and a ⅝-in. screw.

Procedure:

1. To make the base, cut each piece 11 in. long. File the ends round.
2. Grip the end of the stock in a vise to form a volute curve around a small cylinder.
3. Locate and drill two holes diagonally across the middle, and rivet the base pieces together.



DETAIL OF READING LAMP

4. To make the uprights, cut each 20 in. long; round off the lower end and bend the curve. Locate and make the lower and the upper twists, each a half turn in the same direction, but opposite directions for the two pieces. (See drawing.)

5. Drill four holes through the base and the curves of the stem pieces, and rivet the base and the standard together.

6. Bend the upright pieces together above the upper twist, as shown, and locate, drill, and insert a rivet.

7. Bend the stem into a graceful curve, and put in two more rivets. Finish neatly.

8. Twist the end of the stem a quarter turn at D, and open the ends to form a cramp on the ends of clamp C. Then cut off the ends even, drill a hole for the bolt, and file the ends semicircular.

9. Bend clamp C to fit tightly around the bulb socket and into the hinge at D.

10. Saw off the ends, drill a hole for the bolt, and round off the ends. Fit the bolt and wing nut.

11. To make the lamp shade, draw two circles on sheet metal; the outer circle should have a 7-in. radius and the inner circle a 1¾-in. radius.

12. On the large circle, mark off four 6-in. spaces, allowing a ½-in. lap at one end.

13. Draw a line from each mark to the center, transecting the points on both circles.

14. Draw ½-in. strips to support the shade on clamp C. Draw a ½-in. lap, and cut to the lines.

15. Bend the shade to shape. Drill holes and rivet together neatly.

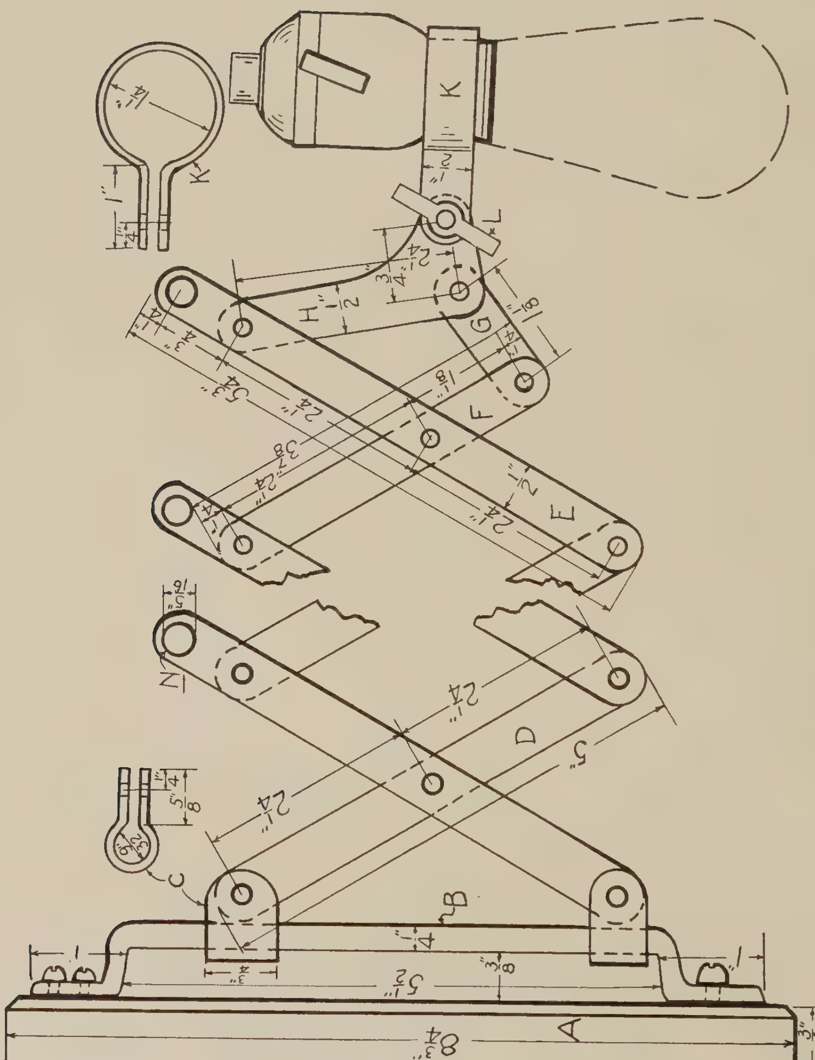
16. Fit the shade strips on clamp C, so that the shade is square with the stand. Locate and drill holes in the strips and the clamp, and rivet them together. Assemble all parts.

QUESTIONS

1. Why should the base of a lamp be large and heavy?
2. What are the advantages of a shade on a lamp?
3. How is insufficient light a detriment to eyesight?
4. Is the light inadequate because it is too far away?
5. How does the strength of light vary with its distance from us?

Problem 43
EXTENSION BRACKET

Subject and Uses: An extension bracket is a desirable fixture for uses such as an extension wall light, a shelf support in connection with a drawing stand, or a telephone holder. The one shown in the drawing may be made to open to any length desired by increasing the number of bars



DETAIL OF EXTENSION BRACKET

proportionately. This bracket is so designed at the support that it may be swung in different directions. When correctly constructed and finished, the fixture is not only highly interesting and convenient, but ornametal as well.

Object of Lesson: Laying out and drilling holes accurately; learning the mechanism of parallel motion.

Tools and Equipment: Vise; iron block; hack saw; drills; file; hammer.

Materials Required: For the wall panel A, 1 piece of ¾ by 5¼ by 8¾-in. oak or walnut wood; for bracket B, 1 piece of ¼-in. steel rod, 9 in. long; for two hangers C, 1 piece of 1/16 by ¾ by 5-in. sheet steel; for six pairs of bars D and E, 1 piece of ⅛ by ½-in. band iron, 68 in. long; for bar H, 1 piece of 1¼ by 2¾-in. steel. For clamp K, 1 piece of 1/16 by ½ by 6-in. brass or steel; a ⅛ by ¾-in. machine screw, and a ⅛ by ¼-in. wing nut; 24 of 3/16 by ⅜-in. button-head rivets; 3 No. 6, r.h. wood screws, ¾ in. long.

Procedure:

1. To make wall panel A, square up, plane, chamfer, polish, and varnish the piece of wood.
2. Cut the ⅛ by ½-in. steel stock to lengths, as per drawing, 5 pieces for D, 6 for E, 1 for F, and 1 for G.
3. Chalk one face, draw a center line, locate and center-punch the center rivet hole, set the dividers, and locate and mark the end holes. Draw and file the semicircular ends.
4. Drill holes for the rivets. Drill holes N for the lamp cord, and slightly countersink both sides.
5. Lay out and drill bar H; saw it to shape, and file to finish.
6. Prepare stock for clamp K; bend it to size, lay it out, drill and file to finish.
7. Rivet the bars together in exact order, and see that the rivet heads are neatly rounded with a rivet header.
8. Prepare stock for hangers C, ¾ in. wide for the top one, and ½ in. for the bottom one. Bend the hangers to size and shape. Lay out and drill holes. Finish them with a file.
9. Slip rod B inside of hangers C, and bend it to exact shape. Flatten the ends with a heavy hammer; lay out and drill holes to fit the screws. Finish with a file.
10. Fasten hangers C to the bars with rivets. Also assemble bars F, G, and H.
11. Fit the socket into clamp K, place the prongs on both sides of bar H, insert the screw, and tighten it with wing nut L.

12. Locate and fasten bracket B on panel A. Wire the socket with a black cord which is run through holes N, to the outlet furnishing the current.

QUESTIONS

1. In mounting the bracket on the wall, why should bracket B be exactly vertical?
2. Why should hangers C have no more play than is necessary to slide freely on bracket B?
3. What would result, if the holes were not drilled exactly in line, in the bars?
4. Is it advisable to make a jig for drilling the bars? Why?
5. When moving the bracket from the folded to the extended position, does the lamp socket maintain a constant vertical direction? Why?

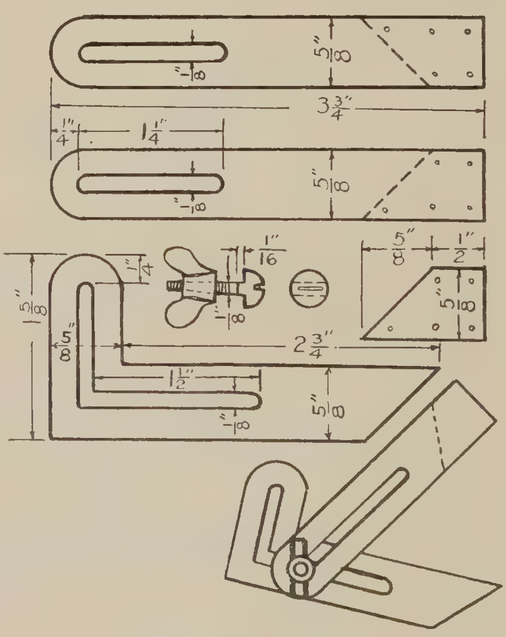
Problem 44
BEVEL

Subject and Uses: This tool is designed in a size most suitable and convenient for the machinist, the toolmaker, the draftsman, and others. The blade is movable between the two plates of the stock, and is fixed at any desired angle by a screw and a wing nut. The two plates of the stock are separated by a short plate at one end where the three thicknesses are riveted solidly together. The slots in the blade and stock plates, facilitate the setting of the blade to different angles and positions. The bevel is used for transferring and laying out angles, and it may be used in connection with a protractor, for determining the number of degrees in a given angle.

Object of Lesson: Fashioning blade and stock; cutting out slots; tapping.

Tools and Equipment: Hack saw; breast drill; small tap; cold chisel; hammer; file.

Materials Required: One piece of 1/16 by 3¼ by 3¾-in. machine steel; one ⅛-in. r.h. machine screw, ½ in. long; 1 wing nut to fit screw; two 6d nails for rivets.



DETAIL OF BEVEL

Procedure:

1. Lay out the pattern for the parts on the metal sheet.
2. With a hack saw, cut to the lines, leaving 1/64 in. for finish.
3. Lay out, space exactly, center-punch, and drill holes for the slots.
4. Cut out the intermediate parts with a fine chisel, and file the slots to the width required.
5. Drawfile sides and edges flat and smooth.
6. File the beveled edge of the short plate, insert it in place between the two long plates, and drill 5 holes for rivets.
7. Countersink for rivet heads, and rivet the parts together. Make rivets out of 6d nails.
8. File the edges straight, and file all other parts smooth and to the required shape.
9. File the underside of the screw head 1/16 in. deep, leaving a shoulder to fit into the slot in the stock to keep the screw from turning.
10. Drill and tap the wing nut to fit the screw. Smooth the nut with a file.
11. See that all edges are straight and square.
12. Give the tool a final finish with a dead-smooth file; polish with oil and emery cloth.

QUESTIONS

1. In setting the bevel on the protractor, why must the edge of the blade be up to the mark at the center of the protractor base?
2. What precaution is necessary when the beam is placed on a flat surface and the blade is being adjusted to an external angle?

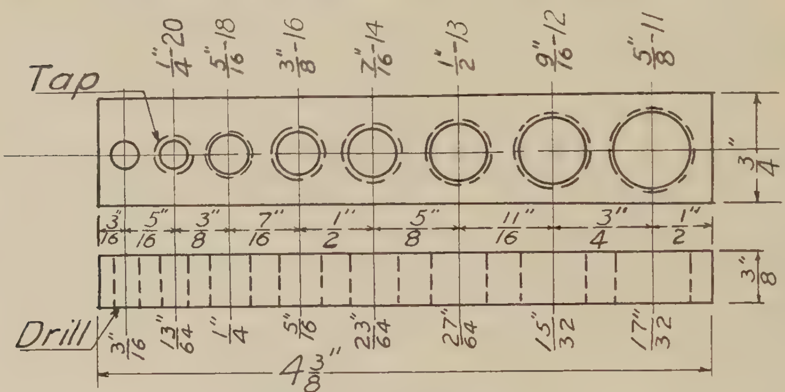
Problem 45

SCREW GAUGE

Subject and Uses: This gauge has a series of holes of different sizes, with standard V thread, tapped to sizes that range in sixteenths from ¼ in. to ⅝ in. inclusive. A gauge of this type is almost indispensable in checking the exact size of a screw. When cutting threads in the lathe, such a gauge is necessary to secure the fit desired for the screw.

Preparatory to laying out the holes, a coat of chalk is rubbed on one side of the metal and spread out evenly with a finger tip, so that when lines are drawn they can be readily seen. On the center line, the holes are spaced, with dividers, to the positions shown in the drawing, and these locations are then center-punched. Circles are drawn the size of each hole. Eight light punch marks on the circle serve as guide marks, after the chalk is rubbed off, to indicate whether the drill keeps to the center or works out to one side. A drill, ½ in. or more in diameter, has a large dead center and easily gets off the mark when the hole is being started. It must then be drawn over to the center by cutting away some

stock on that side of the hole which is inside the circle. This hand cutting is done with a round-nose draw chisel and a hammer. A large hole is usually started by running a small "pilot" drill down a distance. The small drill finds the center mark more easily, and the small hole provides a center clearance which the large drill easily follows. The sizes of drills and taps, to be used, are indicated in the drawing.



DETAIL OF SCREW GAUGE

The tapping is started by fastening the taper tap in the tap wrench, inserting it straight in the hole, pressing down on it as it is being turned clockwise, and then testing to see that it is square with the face of the work. The tap is kept well oiled as it is worked back and forth, to keep it from binding. Jerky motion, severe strain, and clogging the tap with shavings must be avoided, lest the tap be broken.

Object of Lesson: Spacing and drilling holes, true to location and size; tapping.

Tools and Equipment: Drill press or speed lathe; hack saw; drills; taps and wrench; draw chisel; hammer; file; vise.

Materials Required: One piece of ⅜ by ¾ by 4½-in. machine steel.

Procedure:

1. Saw off the stock to the required length, and square it.
2. File the sides parallel and square with the faces.
3. File the ends square with the sides and the faces.
4. On the face center line, lay out holes, as shown in the drawing.
5. Draw circles to size, and make guide marks.
6. Drill all holes, true to sizes and locations. Hold the work in a vise.
7. Start the taper tap square, and turn it as carefully as if it were made of glass.

8. Keep the threads of the tap well oiled. Work the tap back and forth, gaining a half turn forward after each backward swing.

9. Follow the taper tap with the plug tap, turning it clear through the hole.

10. Drawfile the faces of the gauge.

11. With steel figures exactly spaced, stamp the size of the tap and the number of threads, at each hole.

12. Finish all surfaces with a dead-smooth file.

13. Run the plug tap through the holes again, using oil to smooth the threads.

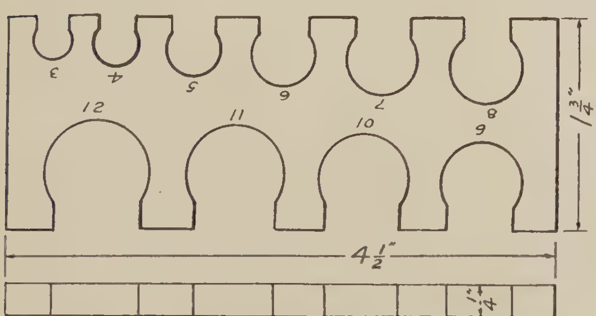
14. Polish the gauge with oil and fine emery cloth to standard finish.

QUESTIONS

1. To make a peripheral speed of 30 ft. per minute, how many revolutions per minute (r.p.m.) must a 1-in. drill make?
2. How is the size of a drill found for a tap of a given size?
3. When feeding by hand, what precautions should be taken as the drill breaks through the metal?
4. In drilling and tapping steel, why is the drill kept lubricated?

Problem 46
MASTER SNAP GAUGE

Subject and Uses: Some machine parts must be made so that they will be interchangeable, and therefore standard gauges are necessary to test the size of such parts while they are being made. Frequently, two gauges are used for each size. One is .001 in. oversize, and is marked "Go," the other is .001 in. undersize and is marked "No Go." "Go" and "No Go" mean that the work must be of a size that will go into the large gauge and still be too big to go into the small gauge. Modern factories have master gauges with which they verify the gauges used in the shop. The gauge shown here ranges by sixteenths, from 3/16 in. to ¾ in., inclusive.



DETAIL OF MASTER SNAP GAUGE

Object of Lesson: To file and lap gauge jaws parallel and to exact measurements.

Tools and Equipment: Drill press and assortment of drill sizes; hack saw; file; oilstone.

Materials Required: One piece of 1/4 by 1 3/4 by 4 1/2-in. machine steel.

Procedure:

1. Finish the stock square and to the correct length.
2. Make a full-size drawing on paper, and paste it on the steel.
3. Center-punch for the holes, located a distance from the edge equal to the radius of the drill plus 1/16 in., and so that the strength of the metal left between the holes shall be uniform. The diameter of each hole should be 1/16 in. larger than the flat opening.
4. Hold the steel in a vise and run a pilot drill through all holes. Then drill to sizes, from 1/4 in. up to 13/16 in., making each succeeding one 1/16 in. larger.
5. Locate the openings carefully and saw them out, leaving 1/32 in. of stock on each side for finishing. Make the cuts square with the edge and the face of the stock. Heat the metal red-hot in a clean fire.
6. File the openings to within .005 in. of the required size, using an inside vernier caliper for testing the measurements.
7. File and drawfile the ends, sides, and faces, to make them straight, flat, square, and smooth.
8. File the jaws of the openings to within .001 in. of the required size, measuring with an inside vernier that has been set to size by a micrometer caliper. The jaw faces must be square and flat for perfect measurements.
9. Stamp each opening with a steel figure to show how many sixteenths it measures; viz., 3, 4, etc., up to 12, inclusive.
10. Caseharden the jaw faces, and rub each with an oilstone to standard sizing block, previously made, for final testing.

QUESTIONS

1. Do stresses exist in pieces of iron, wood, brass, glass, etc.? Why?
2. Do such operations as sawing, drilling, etc., tend to release internal stresses? Why?
3. Why should the gauge be heated after the openings are cut and before they are finished to the sizes required? Why must the gauge be heated in a clean fire?
4. Why does metal often show cracks after heating and quenching operations?
5. What do the cracks indicate?
6. Why should metal be heated slowly and evenly?

Problem 47
HACK-SAW FRAME

Subject and Uses: This type of saw frame is adjustable in length and has extra depth. The style of handle shown here has met with general favor, as it affords a good substantial grip and is strong and firm. The adjusting and tightening post is positive and of durable construction. The stock for the frame may be bent cold. It is marked on the center line of the face with a center punch, 2¼ in. from each end. It is then gripped in a vise, and is bent edgewise over a 2-in. pipe, at the point marked. By slipping a ¾-in. pipe over the end of the stock, the bending is facilitated, care being exercised to bend it in a plane so that buckling does not occur.

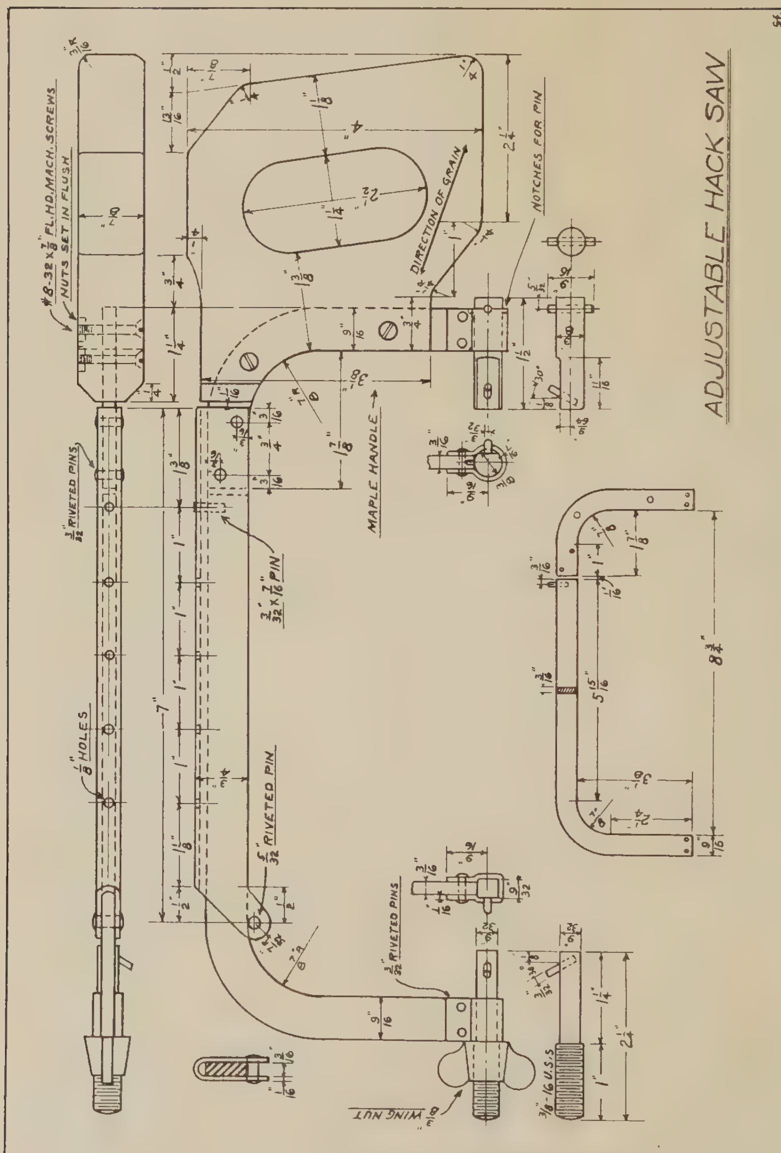
Object of Lesson: Bending steel edgewise; forming handle; making adjustable frame.

Tools and Equipment: Vise; hack saw; breast drill; hammer; file; auger bits; brace.

Materials Required: Machine steel: For brace, 1/16 by 2 by 7¼ in.; for frame, 3/16 by 9/16 by 16 in.; for sockets, 1/16 by ½ by 4¾ in.; for spindles, ⅜ in. round by 4 in. long; ⅜-in. wing nut; for handle, ⅞-in. maple wood, 4 by 5½ in. Two No. 8-32 by ⅞-in. f.h. machine screws; 2 No. 8-32 nuts; 1 wire 5/32 by ½ in. for spacer rivet; for rivets, 3/32 by 4-in. wire; 3/32-in. pin, 1½ in. long.

Procedure:

1. Make the brace as shown in the drawing. Draw a long center line. On both sides of the center line, ⅛ in. and 11/16 in. from it, draw lines.
2. On the lines marked at ⅛ in., bend the stock in a vise 45 deg. on each line. Press the stock into a U shape, and insert the frame stock to get a sliding fit.
3. Lay out an extension at the end for the pin, saw off a slant corner and leave an extra width of the brace to fit the width of the frame. Insert the pin through the extension and rivet it.
4. To make the frame, mark the stock 2¼ in. from each end, grip it in a vise, and bend it edgewise over a 2-in. cylinder at the mark, to a right angle.
5. Saw off stock to the required lengths.
6. Form the sockets, one square and one round, over corresponding shapes, fit them on the ends of the frame, and press them in a vise. Lay out the sockets, drill and rivet them in place, file the notches at right angles, and across the round socket end for the spindle pin. File smooth.



DETAIL OF HACK-SAW FRAME

7. Fit the short frame piece into the end of the brace; drill, and rivet it securely.

8. Lay out and drill 1/8-in. holes into the back of the brace.

9. Fit the frame so that the socket ends are 8¾ in. apart, locate and drill a hole for a pin in the top edge, near the end of the long frame piece. Press the pin into place.

10. Make 3/8-in. spindles, one 1½ in. long, with a 1/8-in. pin 9/16 in. long through it, 5/32 in. from the near end; the other 2¼ in. long, threaded 1 in. long and filed 9/32 in. square for 1¼ in. long.

11. Flatten the side of round spindle, 1/8 in. deep, for a distance of 11/16 in. from the inner end.

12. Drill a 3/32 in. hole on the flat, 1/8 in. from the end, at a 60-deg. slant from the saw blade so as to hook the blade.

13. Press the pin into the spindle, and file it to extend 1/8 in.

14. In the wing nut, drill a 5/16-in. hole, tap a 3/8—16 thread, fashion the nut with saw and file.

15. Make a full-size drawing of the handle on cardboard, and cut out a template.

16. Trace the outline on 7/8-in. maple, and observe the direction of the grain for maximum strength.

17. Bore two 1¼-in. holes on the center line of the finger opening, and finish it to shape.

18. Saw to the outline of the handle, and fashion it to the required contour.

19. Make the groove to fit over the saw frame by sawing two kerfs. Cut out the extra stock.

20. Drill for two screws through thickness of the handle and the frame for the shank.

21. Polish the handle. Apply two coats of shellac, and polish again.

22. Inspect all parts, polish them bright, and assemble them.

QUESTIONS

1. Why should the frame be bent before it is cut to lengths?
2. In bending stock, does it change in thickness at the inner part of the curve? At the outer part? On the neutral axis?
3. What are the different positions that the blade can have in the frame?
4. Why should the spindles be fixed so that the flats are in the same plane?
5. What other design may be given to an adjustable hack-saw frame?

Problem 48
RIVETING AND BRAD HAMMER

Subject and Uses: The attractive feature of this hammer is that it is strong, and that it can be readily made by the young mechanic. It is worth noting that the handle will not break nor come off, as is the case

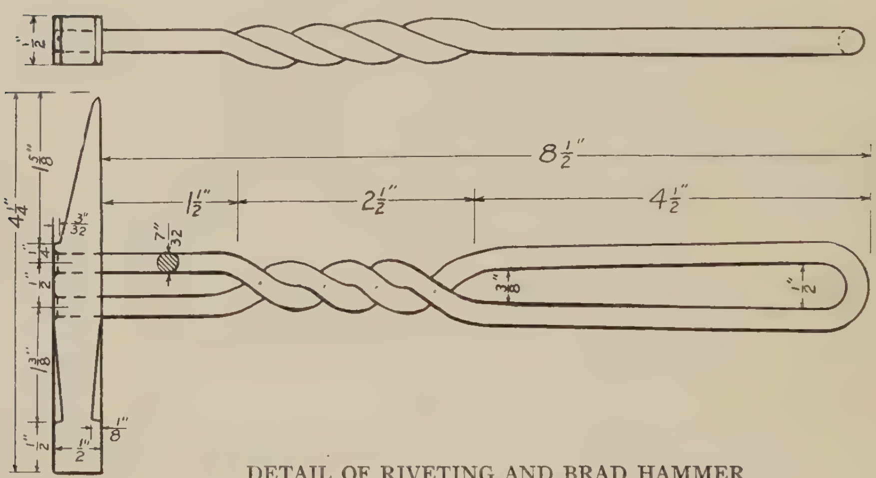
with a wooden-handled hammer, and the shape of the handle affords a firm grip. It is a convenient tool, well proportioned, well balanced, and especially adapted to light riveting.

Object of Lesson: Shaping hammer head; fitting; riveting; twisting; shaping handle.

Tools and Equipment: One piece ½-in. square machine steel, 4¼ in. long, for the head; 1 piece No. 4 copper-coated steel wire, 20 in. long, for the handle.

Procedure:

1. Saw off 4¼ in. of ½-in. square stock for the head.



DETAIL OF RIVETING AND BRAD HAMMER

2. Draw a center line along one face, mark the middle, and at ¼ in. from each side of the mark, center-punch and drill holes for a driving fit on the wire handle.

3. Countersink the holes lightly in one side of the hammer head for riveting the ends of the wire handle.

4. Outline the taper end of the hammer head, and saw off a triangular portion to form the cross-peen shape. Finish the peen end with a file.

5. File the four chamfers on the other end of the head, as shown in the drawing.

6. Drawfile the end and polish the head all over.

7. File the ends of the wire, and taper them to make a tight fit into the holes in the head.

8. Find the middle of the wire, and at that point bend it around ½-in. round stock so that the two halves become parallel.

9. Grip the wire in a vise and drive the hammer head on the wire until the wire ends protrude 1/16 in. Rivet the ends to fill the countersunk recesses.

10. Adjust the wires parallel and grip them in a vise 4 in. below the hammer head.

11. With a monkey wrench, grip the wires 1½ in. below the head, and twist them two complete turns.

12. Grip the head in the vise and twist the wire handle until it is at right angles to the surface of the head. File and polish all parts to a fine finish, and caseharden the ends of the head.

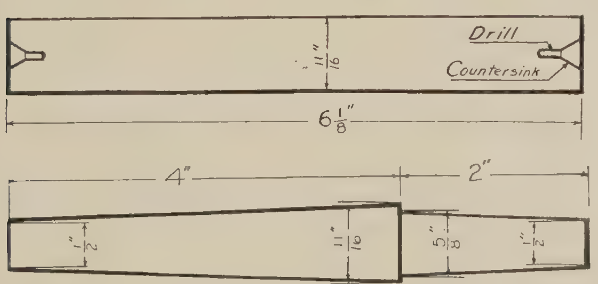
QUESTIONS

1. What is meant by a hammer being well balanced?
2. What elements in its make-up determine the balance of a hammer?
3. Do the twists in this hammer handle contribute to its stiffness?
4. Why is the cross-peen hammer suitable for riveting?
5. Should a hardened hammer be applied directly against the hardened surface of an anvil? Why?

Problem 49

STRAIGHT AND TAPER TURNING

Subject and Uses: As this problem introduces lathe work, the beginner must learn how to get the lathe in running order. On the main body of the lathe called the "bed," three main parts are located: at the left is the head, at the right the tailstock, and in the center is the carriage. Along the top surface of the bed are four tracks, called the "ways." The tailstock slides on the two inner ways, while the carriage slides on the two outer ways. Run the tailstock to the right, and clean the ways with a piece of waste. Then run the carriage as far as it will go, clean the ways and apply a small stream of oil along the edges of the ways, to trickle down their side faces. Run the carriage to the left, clean the ways where the carriage stood, and oil there, too. Also oil all the bearings. This includes the main-spindle and feed-rod bearings, the back gears, the tumbler gears, the apron mechanism, the tailstock screw and spindle, and the countershaft. Examine the live center; it must run true. Run the tailstock center up to within 1/32 in. of the live center. By turn-



DETAIL OF STRAIGHT AND TAPER TURNING

ing the two set-over screws at the sides of the tailstock, make adjustments so that the two centers are in perfect alignment. Examine the workings of the mechanism under the apron. Manipulate the handles for both longitudinal and cross feed. Ascertain how the feed clutch is operated. Adjust the power belt to the correct speed for a ¾-in. spindle. Examine the workings of the tumbler gears, and regulate the feed belt. Investigate the clutch mechanism of the countershaft and learn how to manipulate the shifting rod.

Object of Lesson: To learn how to do straight and taper turning.

Tools and Equipment: Lathe and turning tools.

Materials Required: Machine steel, ¾-in. round, 6⅛ in. long.

Procedure:

1. Saw off the stock to length, taking care that the cut is square with the axis of the material.
2. Rub chalk on the ends and spread it with the tip of the finger.
3. With hermaphrodite caliper, set to the radius of the stock, draw intersecting arcs on the end of the stock, and set a deep punch mark in the center.
4. Put the stock between the lathe centers so that it may be easily spun by hand. While spinning, hold a piece of chalk to mark the high spots.
5. Put the work in the vise, and with a center punch, draw the center over toward the high spots indicated by the chalk marks.
6. Test again on the lathe centers, and make the necessary adjustment to make the spindle run true.
7. With a 1/16-in. drill in the speed lathe or the drill press, drill holes into the ends of the stock ¼ in. deep, and countersink them ⅛ in. deep.
8. Select the proper size dog, and tighten it on the stock flush with one end.
9. Place the spindle on the lathe centers so that the tail of the dog fits loosely into the slot in the faceplate. Put oil on the tailstock center, and run it up against the center of the work. Have the tailstock securely clamped to the lathe bed. Turn the tail center up against the center of the work just firmly enough to eliminate all play and without friction. Lock the tail spindle by turning the clamping handle.
10. Get a diamond-point tool, grind it to the proper angle, and whet it to a keen edge.
11. Mount the diamond point in the tool post so that the cutting edge will be slightly above the lathe centers. Start the lathe by pulling the belt by hand to make sure that all parts are correctly adjusted before throwing on the power.

12. Start the lathe, and watch how the tool cuts; set the caliper to 11/16 in., and adjust the cutting depth to that diameter.

13. When the tool is halfway along the spindle, stop the lathe; release the feed clutch; grasp the work with the left hand; unlock and turn back the tail center with the right hand, and run the carriage to the right so that the tool clears the end of the work. Remove the work from between the centers; put the dog on the other end; clean the centers of work and the tail center with a small piece of waste; put fresh oil on the tail center, and adjust it to form a firm support for the work. Then lock it as before.

14. Start the lathe, bring the tool against the work, and start the feed by tightening the feed clutch. Since the tool remains set the same as at the beginning, the cut on the second half of the spindle will terminate exactly even with the cut on the first half, unless the tool has been moved or the edge becomes dull or broken.

15. Remove the diamond point. Insert in its place the side tool, and adjust it so that the point of the tool will just bear against the work. Start the cut up close to the center, bring the tool slowly out from the center and thus square up, or face the end. Face the other end likewise.

16. Using the same stock, now turn up a No. 2 Morse taper. In figuring taper, the foot is the unit for length, and the inch the unit for difference in diameters. If, in turning a spindle 1 ft. long, the tailstock center is set over toward the tool 5/16 in., the radius of the spindle will be 5/16 in. shorter at one end than at the other; i.e., the diameter will be $\frac{5}{8}$ in. less at one end than at the other, so it tapers $\frac{5}{8}$ in. per foot. It is clear that the set-over equals one half the required taper. To find the set-over, multiply one half the rate of taper, in inches, by the length in feet. In this case, the rate of taper is .602 in. per foot and the length of the work is 6 in. The set-over equals one half of .602 in. $\times$ 6/12 = .1505 in. Set the spring dividers, on a steel scale, to the required set-over. Place one point of the dividers on the zero line of tailstock sub-base and move the tailstock over until the index line on the tailstock coincides with the other point of the dividers. Clamp the tailstock.

17. Sharpen the diamond point, rounding the cutting angle slightly so as to cut a smooth finishing chip. Set the tool on a level with the lathe centers.

18. Take the first cut to run out midway of the length, and test the correctness of the taper. Draw heavy chalk lines along both sides of the tapered portion, and insert it into the standard taper socket. Turn it to the left, and note where the chalk line rubs off. If the chalk is worn off

the small end, then the tail center needs setting off more toward the front, while if the chalk is worn off the large portion, the tail center needs less setting off.

19. With the correct taper obtained, turn both ends to the required diameters, one to fit the lathe socket, and the other to fit the drill chuck.

20. With a dead-smooth file, finish the taper cylinder by running at high speed and by taking long, deliberate strokes overlaping each other. Apply a straightedge along the tapered cylinder. Polish with oil and emery cloth.

NOTE: If polishing is done in the turning lathe, the lathe bed must be well covered to protect it from emery which, by its abrasive action, would damage the ways.

QUESTIONS

1. Why is the tool set above center in turning a straight cylinder?
2. Why is the tool set on a level with the centers in turning a taper?
3. Why should the tool point be as near the tool post as possible?
4. In turning the steel, do the chips curl up in a continuous spiral, or do they break off in short pieces? Why?
5. Does the dead center get warm during the turning process? Why?
6. Do the work and the cutting tool get warm? Why?

Problem 50

THE 60-DEGREE CENTER

Subject and Uses: This center is one of the vital parts of a lathe, and must be kept in perfect shape. The frequent retouching, necessary to keep the lathe centers in trim and true shape, gradually wears them away, and new ones are required. The sockets in the lathe spindles are reamed to fit standard Morse tapers, and so the appliances intended for use in the sockets, such as chucks, drills, reamers, and centers, must have shanks that are turned and finished exactly to that taper. Lathes of different sizes have sockets of different diameters that are numbered 0 for the smallest lathe and No. 7 for the largest lathe. The rate of taper for these diameters varies slightly. The difference in diameter per foot for No. 1 is .600 in.; for No. 2 is .602 in.; for No. 3 is .602 in.; for No. 4 is .623 in; for No. 5 is .630 in.; for No. 6 is .626 in. When it is desired to turn a taper on a spindle mounted between the centers of the common lathe, the tailstock is set over a distance that depends on the length of the spindle for a given taper. If the spindle is 1 ft. long and the taper is ⅝ in. per foot, as it is for No. 7, or the largest lathe, the tailstock would be set over 5/16 in. If the spindle is 6 in. long, that same rate of taper would require a set-over of 5/32 in.

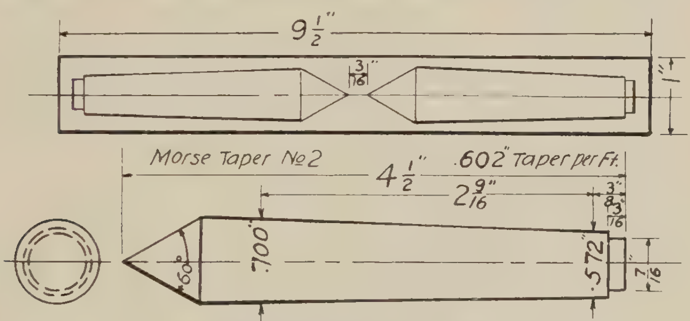
Object of Lesson: To learn how to turn a standard taper.

Tools and Equipment: Lathe and turning tools.

Materials Required: For live and dead centers, round tool steel, 1 by 9½ in.

Procedure:

1. Prepare steel, 9½ in. long, for two centers; drill, countersink, and mount it on the lathe centers.
2. Calculate the amount of set-over, and adjust the tailstock accordingly.
3. Turn a taper on both ends of the stock. Draw chalk lines along the work, and test the taper in a standard socket, by turning the work counterclockwise.
4. Make the necessary adjustment in the taper. Take another cut, and test again. Draw heavy chalk lines along the taper, insert the taper



DETAIL OF 60-DEGREE CENTER

in the socket, twist it to the left, and note where the chalk is rubbed off.

5. Finish the taper to a size to fit perfectly the taper in the lathe assigned.
6. Put the lathe centers in line. Turn the shoulder, face the end, and chamfer the edge of the work.
7. Finish with deliberate strokes of a dead-smooth file. Polish with oil and emery cloth. Finish by grinding, if equipment is at hand.
8. Insert the shank of the work in the lathe-head socket, cut the centers apart, set the compound rest to the required angle, and turn the center point to a 60-deg. angle.
9. Finish centers by filing or grinding.
10. Heat dead center to red heat, right back of the point, and harden by quenching in water. During the heating process, it is well to dip the center point in water to prevent burning.

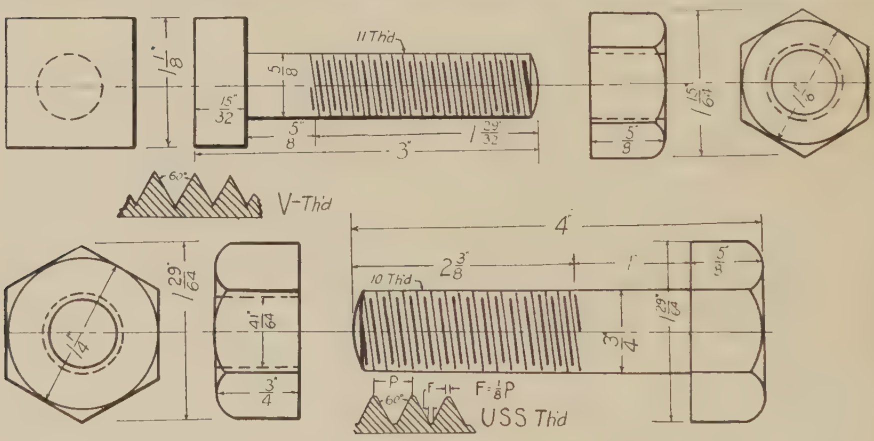
QUESTIONS

1. Of what use is the reduced part at the small end of the center shank?
2. Why is it important that the center makes an exact fit in the lathe spindle?
3. Why is the center made of tool steel?
4. What is the effect on the work if the live center runs out of true?
5. Can the dead center be used if it springs out of true in hardening?
6. Explain the different forces acting on the lathe center, when the lathe center is in use.

Problem 51

MACHINE AND PLANER BOLTS

Subject and Uses: The drawings herewith are of two standard bolts. The one with the square head is called a "planer bolt." It is so called because the head fits into T-slots in the planer table to keep the bolt from turning when the nut is being tightened to fasten the work or the fixtures down to the table. The other, with the hexagonal head, is a machine bolt of standard dimensions, and is used for fastening parts of machines together. These bolts belong to the type generally used in machine construction and have the U.S.S. thread. When the bolt diameter is given, the thickness and diameter of the nut and head may be calculated from that.



DETAIL OF MACHINE AND PLANER BOLTS

Object of Lesson: Shaping head and nut for bolt to standard dimensions; turning parts to exact sizes.

Tools and Equipment: Lathe; chuck; turning and threading tools; taps and drills; hack saw; files.

Materials Required: Round machine steel. 1½ in., for planer bolt and nut, 4 in. long; for machine bolt and nut, 5 in. long.

Procedure:

1. Cut off stock to length in the chuck, for the nut, and face the ends.
2. Drill the axial hole in the nut with the required tap drill.
3. Steady the tap on the tail center. Use oil on the tap, and run it on the slowest speed. Start with taper tap and finish with plug tap.
4. With the radius, step off the hexagonal nut; draw six lines lengthwise on the outer surface, and file down the flats between the lines. This operation should be done on the milling machine, if one is available.
5. Center the stock for the bolt, and mount it on the lathe centers.

6. Face and chamfer the end for the head, and make a shoulder cut for the length of the head, to the required depth, with the parting tool.

7. Reverse the work end for end, and turn the shank down to dimension.

8. Face the shoulder of the head; face and chamfer the end of the bolt.

9. Gear up the lathe, set the thread tool, and cut the thread to the specified length, to the depth required for a firm running fit in the nut, and to a perfect shape and smoothness.

10. Step off, cut away the stock, and file, or mill in a milling machine, the required number of flats on the bolt head. Finish and polish to suit requirements. Caseharden the bolt.

QUESTIONS

1. How may a screw be made to act as a wedge?
2. In tightening a bolt, does the length of the wrench handle affect the pressure developed? How?
3. Is the thickness of the nut greater than that of the head? Why?
4. What is meant by stripping the threads? What causes it?

Problem 52
STUB ARBOR

Subject and Uses: The stub arbor is very convenient and a great time saver for turning pieces such as collars, small pulleys, and other parts of that kind, which have holes drilled and reamed through them. The taper shank of the arbor fits into the lathe spindle. The arbor end is turned to some standard size, and an axial hole is drilled into the end and tapped. The outer end of the axial hole is countersunk to a 60-deg. taper, and the arbor has three radial slits cut as far as the shoulder. The plug which is threaded to fit into the arbor, having a conical taper and a square head, when tightened with a wrench, causes the arbor to expand, and thus to drive the piece of work that is being turned.

Object of Lesson: Turning taper and cone form; cutting slits; threading and shaping square head.

Tools and Equipment: Lathe; turning and threading tools; drill and taps; large countersink; hack saw; file.

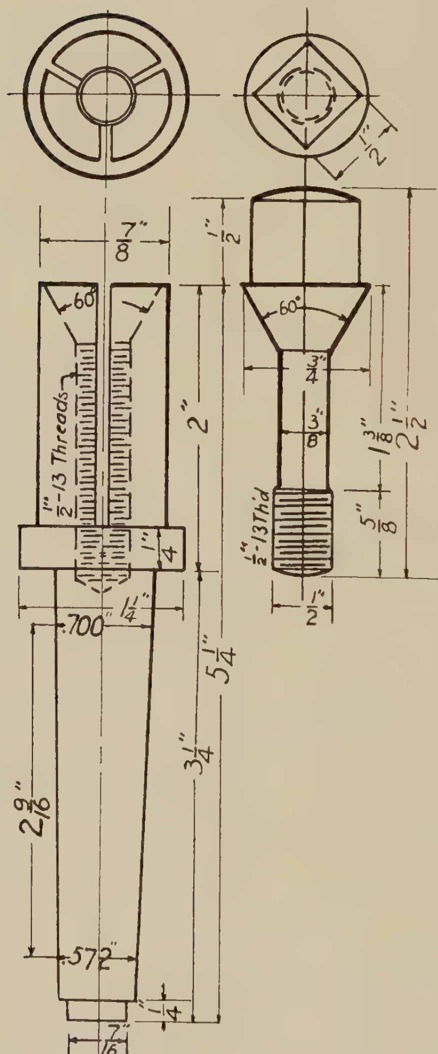
Materials Required: Round tool steel, for arbor, 1¼ by 6¼ in.; for plug, 1 by 3 in.

Procedure:

1. Select stock for the arbor, center and mount it on the lathe centers.

2. Rough-turn and make cuts at both sides of the shoulder, with a parting tool.

3. Turn the taper, and fit it into a standard socket.



DETAIL OF STUB ARBOR

4. Turn a recess at the small end of the taper, and face the ends.

5. Turn the arbor to finish, and face the shoulders.

6. File to finish, and polish work all over.

7. Insert the taper in the lathe-spindle socket, and drill a hole into the end for the tap.

8. Bore out a 60-deg. taper in the end of the arbor, and countersink.

9. Tap out the hole. Lay out the slits 120 deg. apart, and draw lines along the arbor to mark the path of the cut.

10. Cut the three slits with a hack saw. Remove the blade from the hack-saw frame, and finish the slits with the blade gripped in a hand vise, or mill the slits.

11. Center the stock for the plug, and mount it on the lathe centers.

12. Turn the shank to size and finish; face the end and chamfer.

13. Reverse the work, face the end, and turn the head to size.

14. Lay out the head by drawing diagonals, and file it square, or mill it.

15. Set the compound rest to the correct angle, turn a 60-deg. cone, and finish it.

16. Reverse the work. Gear up the lathe and cut the thread to fit the arbor.

QUESTIONS

1. When cutting the thread inside the arbor, what was the cutting action of the tap?
2. In the cutting action, why does each tooth on the tap need clearance?
3. What is the reason for the four flutes in a tap?
4. May the teeth on a tap gain clearance if the teeth are backed off with a file?
5. What shape of file should be used for backing off a tap?
6. Does a tap continue to cut beyond its taper?

Problem 53
ONE-INCH MANDREL

Subject and Uses: The mandrel, or arbor, as it is often called, is a tool which may be pressed into finished holes in work that is to be turned in the lathe, and which provides centers and bearings that fit on the lathe centers. The centers are made large to furnish ample support to withstand the great stresses involved in turning operations. The mandrel is made with a taper of about .008 in. per foot; the nominal size is at the middle or slightly nearer the larger end. Mandrels are generally made of tool steel, but they may be made of good quality machine steel, with the centers casehardened. The ends are turned smaller than the body, so that if any marring of the surface is occasioned by tightening the dog,

there shall be no hindrance to the mounting of the work on a true, smooth surface. The centers are recessed, so that forcing the mandrel into or out of the work will not get them out of true. Presses are made to tighten or loosen the arbor, but when none are available and a hammer is used to drive the arbor, the center should always be protected by a piece of soft metal on which to strike. The mandrel must be well oiled before inserting it in the finished hole, otherwise the work may be scored or the mandrel may be damaged.

Object of Lesson: To learn the reason for turning to exact size, and the importance of keeping the mandrel in perfect shape.

Tools and Equipment: Lathe and turning tools; centering drill and countersink; forge; filing and grinding facilities; 2-in. micrometer calipers.

Materials Required: Round 1⅛-in. machine steel, 9¼ in. long.

Procedure:

1. Prepare the stock to length, locate the center, drill a 3/32-in. hole, ⅜ in. deep, and countersink ¼ in. deep to a 60-deg. angle.
2. Mount the work on the lathe centers, and face the ends.
3. Turn the recess into the ends 1/16 in. deep and 1/16 in. larger than the countersunk diameter.
4. Turn each end of the mandrel to a ⅞-in. diameter, ⅞ in. long.
5. Round off the edges and polish the ends. File flats for the setscrew of the dog.
6. Caseharden the mandrel, heat each end to a bright red, rub some potassium ferrocyanide into the center and on the end, reheat, and quench in water.
7. Clean and polish the centers. Mount the mandrel in the lathe and turn it to 1 1/32 in. diameter.

DETAIL OF ONE-INCH MANDREL

8. Set over the tail center, and turn the mandrel to .008-in. taper per foot.
9. Turn to size, allowing .002 in. for a ground or a file finish. Use a micrometer for the fine measurements. Mandrels of different sizes may be made in a manner similar to that described.

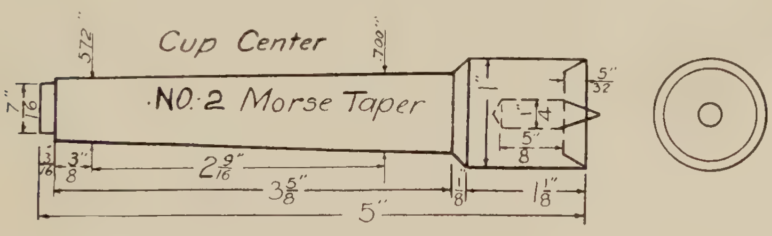
QUESTIONS

1. Why should the centers in a mandrel be larger than those of similar-size spindles?
2. Why should mandrel centers be polished smooth, and hardened?
3. If the hole through the work is short, how may the mandrel be guided straight into the hole?
4. If a pulley with spokes is to be turned on a mandrel, how may it be driven without the use of a dog?
5. When turning work on a mandrel driven with a dog, what prevents the work from turning or sliding?
6. Why is the larger end of a mandrel put on the live center when possible?
7. Is it always possible? Why?
8. Why is the size stamped on the large end of a mandrel?

Problem 54
CUP CENTER

Subject and Uses: The centers for wood-turning lathes are different in shape from speed-lathe centers and from those in the engine lathe. In the wood-turning lathe, the one in the tailstock is called the "cup center" on account of the cup-shaped rim that serves to give the wood, in the lathe, a center of considerable area and strength, in addition to the slender central pivot. The latter protrudes beyond the rim of the cup, and acts as a pilot point in centrally locating the cup center on the end of the wood.

Object of Lesson: Learning how to make the cup center.



DETAIL OF CUP CENTER

Tools and Equipment: Lathe; chuck; drill; turning tools; pointed cupping tools.

Materials Required: Round machine steel, 1 1/16 by 5 in., for cup center; round drill rod, ¼ by 1¼ in., for pin.

Procedure:

1. Grip the stock in the lathe chuck, and with a pointed tool, turn the cup to dimensions, and center the end.

2. Center the other end, and mount it on the lathe centers.

3. Set the lathe to taper, and turn the shank to a No. 2 Morse taper to fit the lathe spindle.

4. Turn the shoulder at the small end, chamfer the edge, face the end, and finish it.

5. Turn the large end to dimensions, and finish.

6. Drill a 15/64-in. axial hole ⅝ in. deep into the large end, for the pivot.

7. Fit the pin and drive it into the axial hole.

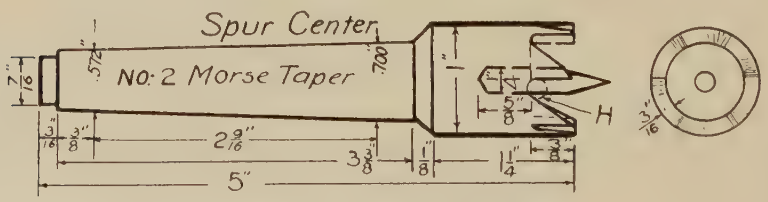
8. Insert the cup-center shank in the lathe spindle; turn the pivot to a point, and to protrude ⅛ in. beyond the rim of the cup. Finish all parts perfectly, and dress smooth.

QUESTIONS

1. Is the cup part of this center necessary? Why?
2. In what direction is the pressure on the cup center, when wood is being turned?
3. What causes the vibration of the lathe, in turning a spindle, when the cup center is not in line with the spindle axis?
4. What makes the wood break in pieces when rotated too fast?
5. What is meant by centrifugal force?

Problem 55
SPUR CENTER

Subject and Uses: The live center in the wood-turning lathe also is called the "spur center." It has projecting spurs, or prongs, that serve as drivers for the wood which is mounted on the lathe centers to be turned. The central pivot protrudes beyond the spurs and functions as a pilot to centrally locate the spur center on the end of the wood. By means of a mallet, the center is driven into the wood, to afford the spurs a strong driving grip to overcome the resistance of the cutting action of the turning tool. It will be noted that the greater the diameter of the center and the more prongs it has, the stronger is its driving grip on the wood.



DETAIL OF SPUR CENTER

Object of Lesson: Counterboring; turning taper; shaping spurs.

Tools and Equipment: Lathe; chuck; drill; turning and boring tools; hack saw; file.

Materials Required: Machine steel: For spur center, 1 1/16 by 5 in. long; for pin, ¼-in. drill rod, 1½ in. long.

Procedure:

1. Grip the stock in the lathe chuck, and, with a pointed tool, turn out the recess in the end, drill, and countersink. Center the other end of the stock.
2. Lay out the six prongs, drill ⅛-in. holes H; saw three diagonal cuts across the end; saw off the six triangular portions; file the prongs to shape.
3. Mount the work on the lathe centers. Set the lathe to a taper of .602 in. per foot.
4. Turn the shank to a No. 2 Morse taper, and fit it to the lathe spindle.
5. At the small end of the shank, turn the shoulder, face the end, and chamfer the edge. Then finish it.
6. Turn the large end to dimensions and finish.
7. Drill a 15/64-in axial hole into the large end, ¾ in. deep, for the pivot.
8. File the drill rod to fit the hole, and drive it in place.
9. Insert the center in the lathe spindle, and turn the pivot to a sharp point, protruding ⅛ in. beyond the spur points.
10. File and polish all parts to a perfect finish.

QUESTIONS

1. Why is one side of a prong straight in line with the axis of the center?
2. Why is the other side of a prong slanted?
3. Why is it important to have the straight side of the prong facing in the direction that the lathe rotates?
4. Why is the center driven on the work instead of driving the work on the center, obviating the removal of the center?
5. Of what metal should the ramrod (which is used for removing the spur center from the lathe) be made?
6. What factors should be considered in determining the speed for turning a wooden cylinder?

Problem 56
HAND CLAMP

Subject and Uses: The hand clamp is a very useful adjunct to any mechanic's tool kit. The frame can be cut from a piece of bar steel. The sizes given here may be changed to accommodate the material on hand or because of some other special requirement.

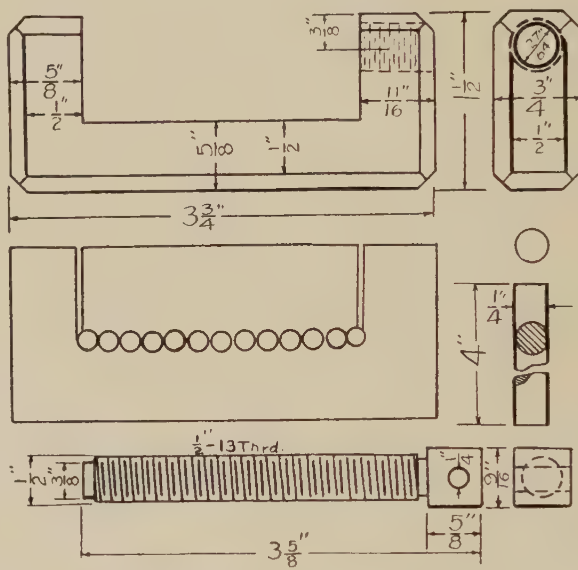
Object of Lesson: Cutting out rectangular metal portion; threading slender screw.

Tools and Equipment: Lathe, and thread tool; tap and drills; hack saw; cold chisel; file.

Material Required: Machine steel: For frame, ¾ by 1½ by 3¾ in.; for screw, ¾ in. round, 3¾ in. long; for handle, ¼ in. round, 4 in. long.

Procedure:

1. Lay out the stock with a square, and saw off a piece of the required dimensions for the frame.
2. Draw a center line on one face, lay out the holes ¼ in. apart, and center-punch.
3. Drill ¼-in. holes perpendicular to the face.
4. Draw lines for the jaws, and make cuts with a hack saw.
5. Cut through the portions between the holes, from both sides, with a cold chisel.
6. Chip off the rough parts, and file smooth and square.



DETAIL OF HAND CLAMP

7. Center-punch both ends, and drill a 27/64-in. hole through one end, on center. Tap ½-in. — 13 thread.
8. Chamfer the outer, back, and end edges.
9. Drawfile all faces, and polish them smooth in oil and emery.
10. Center the stock for the screw and turn the shank to ½ in.
11. File the head square and drill a ¼-in. hole through it for the handle.
12. Face the ends, and turn down the neck and end of screw to ⅜ in.
13. Cut the thread ½-in. — 13, to fit the thread in the frame without play, but so that the screw turns easily.
14. Caseharden all wearing parts of the frame and the screw.
15. Put the handle in place, upset the ends to form the heads, and file them round and smooth.

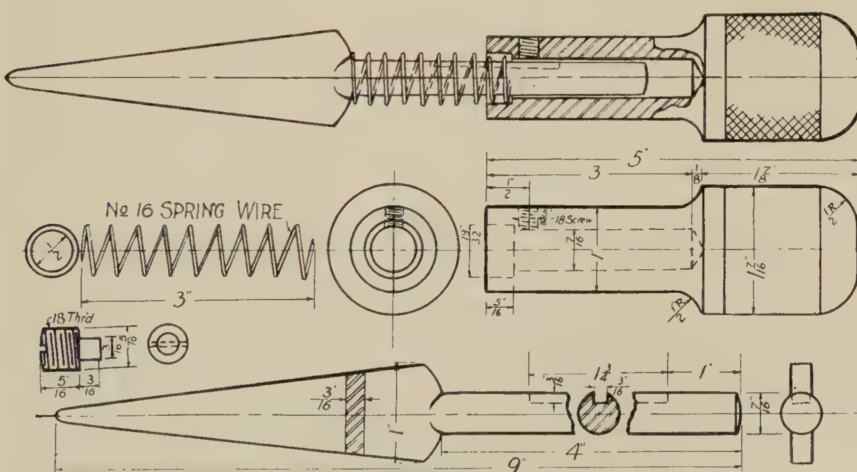
QUESTIONS

1. In drilling deep holes of small diameter, what precaution must be taken to prevent the drill from breaking?
2. When drilling holes ⅜ in. or more in diameter, should a small drill be run in ahead of the larger one? Why?
3. In sawing rectangular stock, how can you prevent breaking saw teeth when cutting into an edge?
4. How would you saw thin stock? How would you hold it in the vise?
5. What effect has a broken saw tooth on the work it is doing?
6. Will the blade break if pushed too hard? If the frame is tipped sideways?

Problem 57
AUTOMATIC DRIFT

Subject and Uses: Anyone who has had experience in operating a boring machine, a drill press, or any other machine where the drift is in frequent use, will appreciate one that can be worked with one hand. This advantage is embodied in the automatic drift, and is a great convenience. It is compact, and self-contained, and does not require a hammer. It is equipped with a heavy handle that slides on the shank and a coiled spring that causes the handle to rebound after each blow, making it possible to extract a drill, shank, or boring bar with one hand, leaving the other hand free to grasp the tool. A setscrew in the handle, with the point projecting into a slot in the shank, keeps the assembled parts from coming apart. The drift is suitably tapered to a point, and is thus readily inserted into the slot in the spindle.

Object of Lesson: Turning curve; knurling; forging and shaping drift; cutting slot; winding spring; casehardening.



DETAIL OF AUTOMATIC DRIFT

Tools and Equipment: Lathe; turning and knurling tools; drills; ¼-in. tap; gas torch; hammer; anvil; files.

Materials Required: Round machine steel: For handle, 1½ by 5¼ in.; for drift, ⅝ by 8¾ in.; for spring, No. 16 wire, 14 in. long; 5/16—18 headless setscrew, ⅜ in. long.

Procedure:

1. Prepare the stock required for the handle and the drift; lay out and center it.
2. Mount the stock for the handle on the lathe centers, and face the ends to length.
3. Turn the small end to the shape and dimensions as shown in the drawing.
4. Reverse the work, turn the large part, and knurl.
5. Round off the end, file it smooth to finish, and polish all smooth surfaces.
6. Drill a 7/16-in. hole into the small end, 3 in. deep.
7. Counterbore for the spring with a 19/32-in. drill, 5/16 in. deep.
8. Drill a 17/64-in. hole for the setscrew, ½ in. from the end, and tap it for 5/16 — 18 thread.
9. Get a screw from stock, or run a die over 5/16-in. stock; file it to a flat point.
10. Cut off the screw to length, saw a screw-driver slot, and caseharden the point.
11. Mount the stock for the drift on the lathe centers, and face one end.
12. Turn the shank to 7/16 in. for a 4-in. length, to a sliding fit in the handle.
13. Heat the drift end in a gas torch to a red heat, and hammer it flat to 3/16 in.
14. Lay out the shape of the drift from the center line, and saw off the surplus stock.
15. File the drift to shape, and finish it neatly all over.
16. On the shank, in a straight line, lay out and drill a series of 3/16-in. holes, 5/32 in. deep, for the keyway.
17. Cut the slot clear with a small chisel, and file it smooth.
18. Wind the No. 16 spring wire on the 7/16-in. rod, gripping it and the end of the wire in the chuck, and making the turns 5/16 in. apart.
19. Caseharden the drift. Heat it red-hot; rub some powdered potassium ferrocyanide on the hot surface, reheat and quench it in water.
20. Assemble the drift by slipping the spring into place, the shank into the handle, and then turn in the setscrew so that the point works smoothly in the slot and acts as a stop.

QUESTIONS

1. What size round stock is required to forge a drift 3/16 in. thick and 1 in. wide?
2. If the stock is too small for the required width of the drift, would upsetting it at the point where the greatest width is located be advisable?
3. How may heat be concentrated at the point where the upsetting is to be done?
4. Why does a blow with a sledge work more effectively in upsetting than several hammer blows?
5. Does the inertia of the stock, between the hammer contact point and the upsetting point, enter into consideration? Why?

Problem 58
BENCH VISE

Subject and Uses: This vise operates with two jaws and two screws like parallel hand clamps. One jaw, having the lower end forged to a broad base, is fastened to a bench with screws, resulting in a substantial tool for holding objects fixed while working on them. The jaws are kept parallel by turning the nut on the lower screw to a point agreeing with the jaw gap required for holding the work. The making of the vise provides a variety of tool operations and thus affords excellent training in machining metals.

Object of Lesson: Practice in heating, drawing out, flattening and bending vise jaw; hardening jaw plates; sawing, drilling, turning, facing, threading, knurling, tapping, fitting, and finishing metal.

Tools and Equipment: Forge and tools; lathe and tools; vise; hack saw; drills; taps; file.

Materials Required: For jaws, ¾ by 1½ by 13-in. machine steel; for jaw plates, ¼ by 1 by 4¼-in. carbon steel; for screw D and balls H, ¾-in. round M.S. 6¼ in. long; for screw E, ½-in. square M.S., 3¾ in. long; for handle G, 5/16-in. C.R.S., 4¼ in. long; for pin J, ¼-in. drill rod, 1 9/16 in. long; for nut F, 1½-in. round M.S., ½ in. long; for collar K, 1-in. round M.S., ⅜ in. long and 1 No. 8–36 headless set-screw; for jaw plates, 4 f.h. screws, 3/16-in. 24 or No. 10–30, 1 in. long.

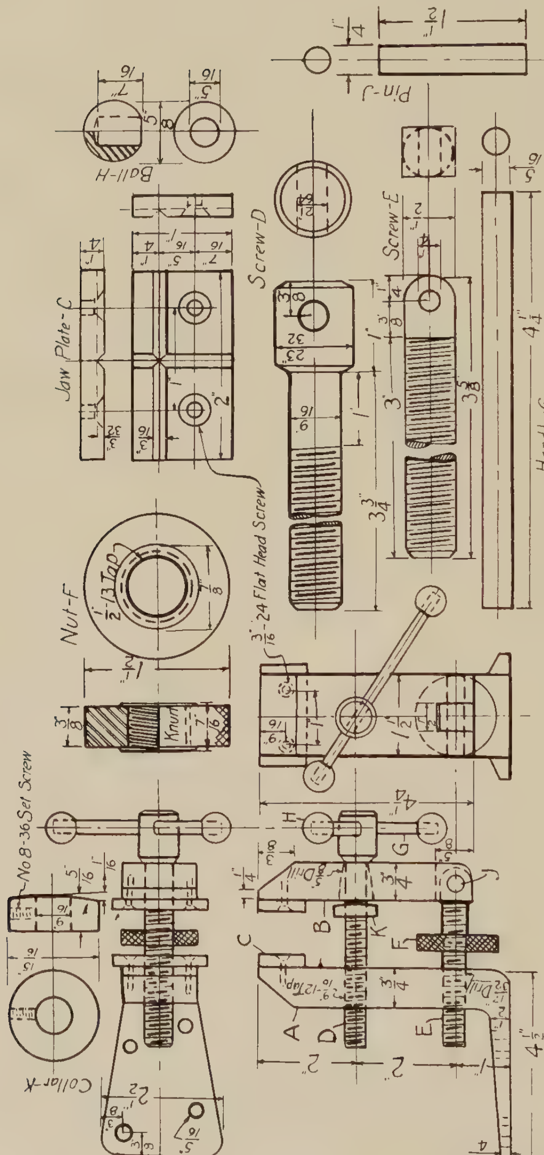
Procedure:

1. Cut off one piece of stock, enough for both jaws; heat the end to bright red; draw it out to dimensions; bend at right angles; make the base bottom flat.

2. Saw the two jaws apart to the angle shown in the drawing and finish to shape and dimensions.

3. Lay out holes for screws in jaw A. For D, drill a 15/32-in. hole and tap 9/16–12. For E, drill a 17/32-in. hole. Lay out the base, and drill 4 holes for 5/16-in. lag screws.

4. Lay out holes for screws in jaw B. For D, drill a ⅝-in. hole and file to permit the screw an up-and-down swing at the inside of the jaw.



DETAIL OF BENCH VISE

Lay out a gap for the hinge on screw E, drill a 15/32-in. hole, saw out stock, and file to size. Lay out and drill from both sides, the 1/4-in. hole for pin J.

5. Prepare stock for jaw plates C, and shape the plates to dimensions, on a miller or a shaper, or with a file. Lay out, drill and countersink for screws.

6. Fit the plates on jaws A and B. Drill and tap the jaws for 3/16-in. 24 or No. 10–30 f.h. screws, 1 in. long.

7. Heat plates C to a bright red and quench in oil. Fasten them on jaws A and B.

8. Grip the stock for screw D in a lathe chuck. Make the 2 balls H by drilling a hole to a press fit on handle G. Turn to a sphere, polish and cut them off.

9. Hold the stock for collar K in a lathe chuck. Drill a 9/16-in. hole through the center. Finish one face flat, the other convex. Drill and tap for a No. 8–36 setscrew. Take the screw from stock, cut off the head to length, saw a screw-driver slot, and fit it into collar K.

10. Grip the stock for nut F in a lathe chuck, and finish one face in the chuck. Finish the other face and the top surface later on screw E.

11. Center the stock for screw D and mount it on lathe centers. Turn it to a press fit in collar K. Turn and finish collar K; then remove it. Cut the thread to fit the hole perfectly in jaw A. Finish the screw and the screw head, and chamfer the shoulders on the screw head. Drill a hole for handle G, accurately, at right angles, and through the axis of the head of screw D.

12. Center the square stock for screw E. Turn and cut the thread to fit nut F. Finish the square end later.

13. Turn the nut F (finished face first) on screw E. Finish-turn, and knurl nut F. Remove the nut from the screw.

14. Drill a hole through the head of screw E to fit pin J. File the end semicircular, concentric with the hole, and fit it as a hinge in jaw B. Insert pin J, slightly rivet the ends, and file flush.

15. Assemble all parts of the vise by finishing to minute details, and fitting them to perfect working condition.

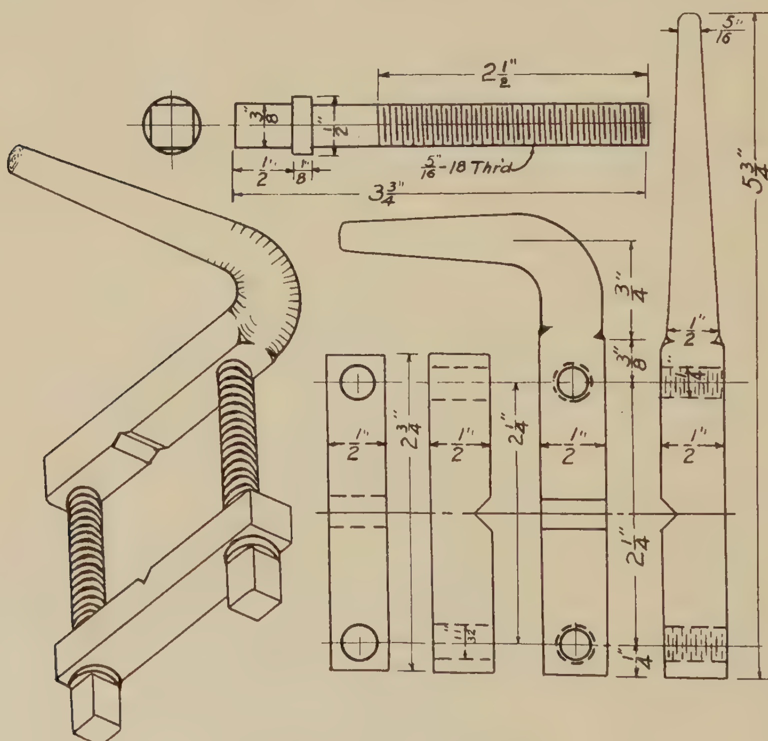
QUESTIONS

1. In measuring wire, how does the wire size vary with the gauge number?
2. How are sizes of common nails and brads designated?
3. How are wood screws specified? Describe a coach screw.
4. How are U. S. S. machine screws specified?
5. Compare Society of Automobile Engineers (S. A. E.) screws with the U. S. S.
6. Describe a S. A. E. bolt. How does it differ in form and substance from a U. S. S. bolt?

7. How does the internal diameter of common water pipe vary from the nominal diameter?
8. What is the shape, pitch, and taper of pipe thread?

Problem 59
CLAMP DOG

Subject and Uses: This appliance is used for driving the material being turned in a lathe. It is superior to the common lathe dog in that it will grip stock, ranging in diameters from the smallest size up to two inches. It is light and handy, and may be readily made from square stock. One of the jaws is turned to a taper and then is bent to the required shape.



DETAIL OF CLAMP DOG

Object of Lesson: Exact centering; taper turning; drilling and tapping; turning and threading slender spindles; bending cold metal.

Tools and Equipment: Lathe; turning and threading tools; drills and taps; vise; file.

Materials Required: Machine steel, for jaws, ½ in. square, 8¾ in. long; for screws, ½ in. round, 7¾ in. long.

Procedure:

1. To make the jaws, saw off the stock to lengths. (See drawing.)
2. Center the long jaw, accurately, and mount it on lathe centers.
3. Set over the tail center, and turn the end of the jaw for a length of $2\frac{7}{8}$ in., to a taper of 1/16 in. per inch.
4. Locate holes on the short jaw, $1\frac{1}{8}$ in. from the middle point, and drill $\frac{1}{8}$-in. holes exactly on the center line.
5. Use the short jaw as a template on the long jaw to drill $\frac{1}{8}$-in. holes.
6. Grip the long jaw in a vise, slip a $\frac{1}{2}$-in. pipe $2\frac{1}{4}$ in. over the tapered end, and bend it at a right angle.
7. Drill $\frac{1}{4}$-in. holes through the long jaw, and tap it with a 5/16—18 thread tap.
8. Drill 11/32-in. holes through the short jaw.
9. Grip both jaws in a vise, and locate and file notches across the middle.
10. To make screws, saw off stock to length for each.
11. Center the screws carefully, and mount them on centers.
12. Take a roughing cut to 11/32 in. and a finish cut to 5/16 in.
13. Face up the ends, square up the shoulders, and cut a line to mark the width of the shoulder.
14. File a square head to shape and dimension.
15. Cut threads on the screws, on the lathe centers, to fit the 5/16—18 threads in the long jaw, firmly, and for a $2\frac{1}{2}$-in. length.
16. Polish the smooth parts of the screws. Drawfile the jaws, finish the ends, smooth and polish them in oil and emery, all over. Caseharden the screws and the jaws.

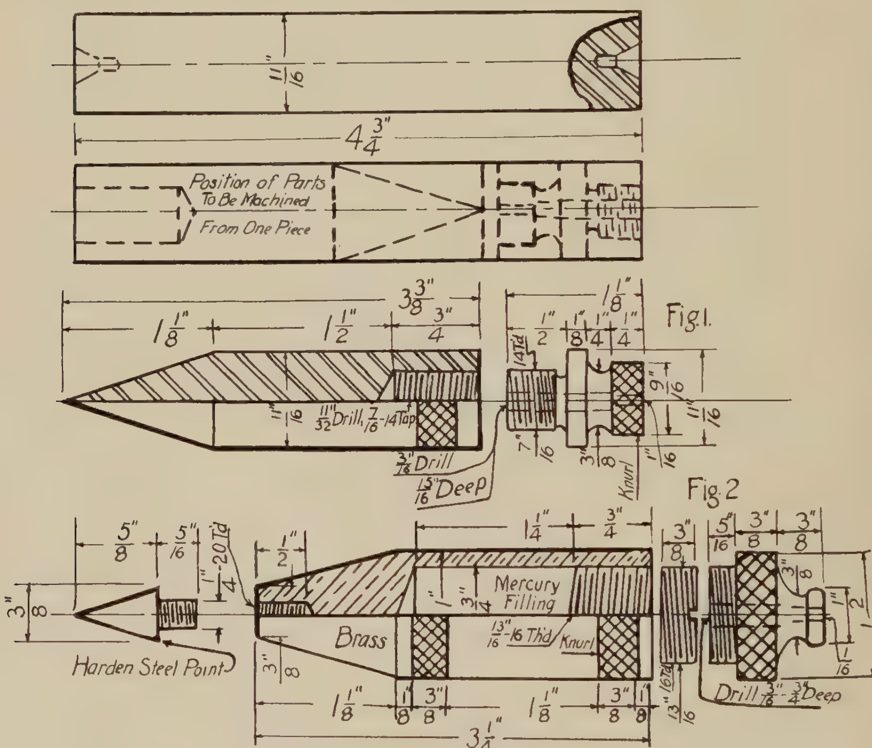
QUESTIONS

1. In locating the holes in the jaw, is a center line needed? Why?
2. Why is one jaw used as a template for the other?
3. Why should the thicknesses of the metal on both sides of the hole be equal?
4. Why is it essential that the holes in the jaw are tapped straight?
5. In cutting the threads on the slender spindles, what precautions must be taken?
6. Is it advisable to start cutting the screw thread on the lathe and finish it to size with a die? Why?

Problem 60
PLUMB BOB

Subject and Uses: A plumb bob is a weight attached to a line to hold the line taut, so that it will indicate a vertical direction from a given point on a surface. Surveyors use it on the transit, and builders in laying out piers and in erecting frame structures, etc. It is essential that the plumb bob be well balanced so that the line of suspension passes

through the center line and through the point of the bob. To this end the cap is made removable, having a thread that screws into the bob, a hole through its center for the string to pass through, and space for a knot on the end of the string. If the bob is made of brass it must be provided with a hard, steel point. When made of machine steel, the bob may be made in one piece, merely casehardening the point.



DETAIL OF PLUMB BOB

Object of Lesson: Fitting threads; knurling; turning taper to point.

Tools and Equipment: Lathe with chuck; knurling, thread-cutting and other tools.

Materials Required: Round machine steel, ¾ in. by 5 in. long.

Procedure:

1. Cut off stock to length, center, and countersink it.
2. Turn stock to 11/16-in. diameter.
3. Cut the neck with a parting tool to a ⅜-in. diameter, forming a shoulder, ½ in. from the end.

4. Cut with a parting tool to ⅜-in. diameter, ¾ in. from the same end, and turn a concave neck ¼ in. wide.

5. Turn the top part of the cap to a 9/16-in. diameter and knurl.

6. Cut a 7/16—14 thread at the end to fit the standard tapped hole in a running fit.

7. File smooth, and polish all over.

8. Drill a 3/16-in. hole into the center of the cap 15/16 in. deep, and drill a 3/16-in. pilot hole ⅝ in. deep in the bob end.

9. Drill the cap end ¼ in. deeper, using a 1/16-in. drill.

10. Using an 11/32-in. drill, enlarge the bob end, making it ¾ in. deep.

11. Tap the bob end with a 7/16—14 thread tap. Avoid striking the bottom, because the tap may break.

12. Mount the chuck in the lathe, grip the stock, and face the ends to finish.

13. Turn the taper point to size, and finish the top of the cap before cutting it off.

14. Finish the point of the bob, file it smooth, and polish all over.

15. Caseharden the point, polish it bright, inspect for finish, and assemble.

QUESTIONS

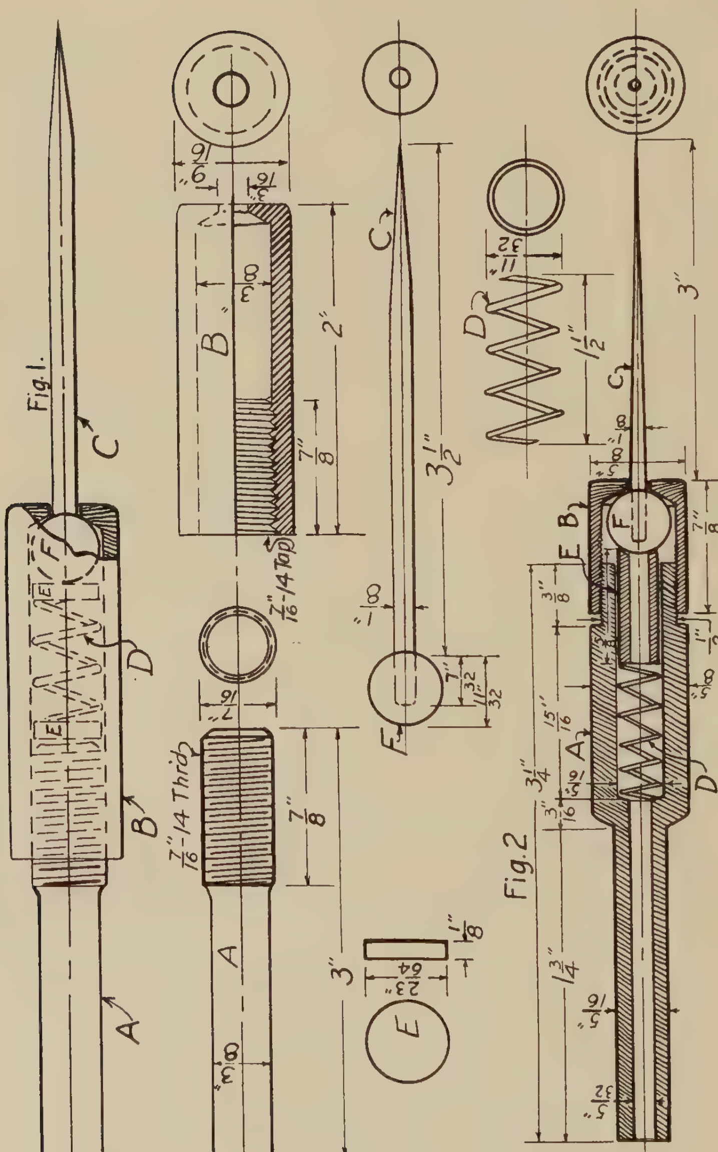
1. How many revolutions per minute should a 1/16-in. drill make in a peripheral speed of 30 ft. per minute?
2. How may finished work be gripped in the chuck without marring it?
3. When drilling into the end of stock, held by hand against the tail center, why should it be turned slowly?
4. When is it advantageous to have the work turn with the drill held stationary?

Problem 61

WIGGLER INDICATOR

Subject and Uses: A wiggler is a device adapted for use in machines, such as the milling machine, the drill press, and the lathe, where work must be set up to given lines or layouts. The shank of the wiggler is held in a drill chuck, with the sharp point or needle so mounted in the holder, that it may be made to run perfectly true, irrespective of how the holder wabbles. The lines drawn on the work may be brought into alignment with the point of the needle. Moreover, where the work is mounted on the lathe faceplate, by inserting the needle point into the center-punch mark on the work and rotating the work, the wiggler point will indicate how much the work is out of alignment and the work may then be adjusted until the point runs true. A magnifying glass is a great aid in detecting the exact intersection of crosslines on work.

The wiggler shown in the drawing is made of the spindle A, screwed into the sleeve B, exerting adjustable pressure through washers E and



DETAIL OF WIGGLER INDICATOR

spring D, on ball F. The pointer C is fastened in ball F, and passes through the hole in the end of the sleeve B; where some play is given the needle C, to swing about when pressure is brought to bear on the needle point. The firmness with which the needle stays in position may be regulated by turning the sleeve, and thus varying the friction between ball F and the cup seat inside and at the end of sleeve B.

Figure 2 shows, in section, a style of wiggler of slightly different construction. The cap B is screwed on the body A, the outer surface of both being knurled, except the shank of A, which is straight and smooth and is a means for holding the wiggler. The hole through the body is large one third of the way, so as to hold the spring D and plunger E. It is small the remainder of the way, thus affording a shoulder for the spring and a pocket for the needle. The plunger E, being cup-shaped on the end next to ball F, offers pressure on ball F and a seat for it that controls the position of the needle. In this manner, the ball is held under pressure transmitted from the spring D, through the loose-fitting plunger E, against the concave, inner surface of the cap. The plunger has a hole through it so that the needle may be slipped inside the holder and then be protected when not in use, simply by unscrewing the cap, inserting the needle through the axial hole through the holder, and replacing the cap.

Object of Lesson: Annealing; drilling and shrinking ball on needle; drilling, tapping; cutting threads; shaping and seating needle; winding spring.

Tools and Equipment: Lathe; chuck; tap; drills; turning, threading, and knurling tools; file.

Materials Required: Round machine steel, for spindle, ½ by 3 in.; for sleeve, ⅝ by 2 in.; 11/32 in. steel ball; for needle, ⅛ by 4 in. drill rod; two washers, ⅛ by 23/64 in.; for spring, No. 20 spring wire 5 in. long.

Procedure:

1. To make the wiggler in Figure 1, prepare stock for sleeve B, and mount it in the lathe chuck.

2. Drill a 3/16-in. hole through the stock, true and straight, face the ends, and countersink.

3. Mount the work on lathe centers, turn it to 9/16 in., and knurl it the full length.

4. Grip it in the lathe chuck, and drill a ⅜-in. hole through the stock to within ⅛ in. of the end. Tap a 7/16—14 thread, ⅞ in. deep. Round off the sharp edges, but put soft sheet-copper strips under the chuck jaws to protect the knurling.

5. To make the spindle, center the stock, turn it to dimensions, and cut the thread to a running fit in the sleeve. Face the ends, file, and polish.

6. Anneal ball F, and drill a 7/32-in. hole three fourths of the way through.

7. Grip the stock for needle C in the lathe chuck, file one end to a shrink fit in ball F, and file the other end to a long tapered needle point.

8. Heat the ball red-hot, insert the blunt needle end into the hole in the ball, quench it in water, and polish.

9. Make the two washers from flat stock by drawing a circle, and sawing and filing to line for a running fit in sleeve B.

10. Wind a spring from No. 20 spring wire, around a 1/4-in. round rod. It is wound open and is compressed between the washers inside of sleeve B.

11. Assemble the parts, and make the necessary adjustments and tests.

QUESTIONS

1. What are the uses of a jig?
2. Enumerate the advantages in using a jig?
3. Why is it imperative that holes in a jig be laid out and bored exactly to measurements?
4. How does the wiggler aid in setting the crosslines on the work exactly in alignment with the drill spindle axis?
5. Which one of the two wigglers do you prefer? Why?

Problem 62
TELESCOPE JACK

Subject and Uses: This jack may be shortened to 2 3/8 in. and extended to 5 in., which is a great range of adjustment for a tool of this size. The top is ball bearing so the cap may assume the direction of the imposed surface, and the lower edge of the cap is slotted and compressed so it cannot come off the ball that fits inside. The parts will be referred to as A, B, C, and D, as designated in the drawing. It should be noted that the threaded parts fit together without the least play, and yet, because of the knurled surfaces, may be turned with the fingers.

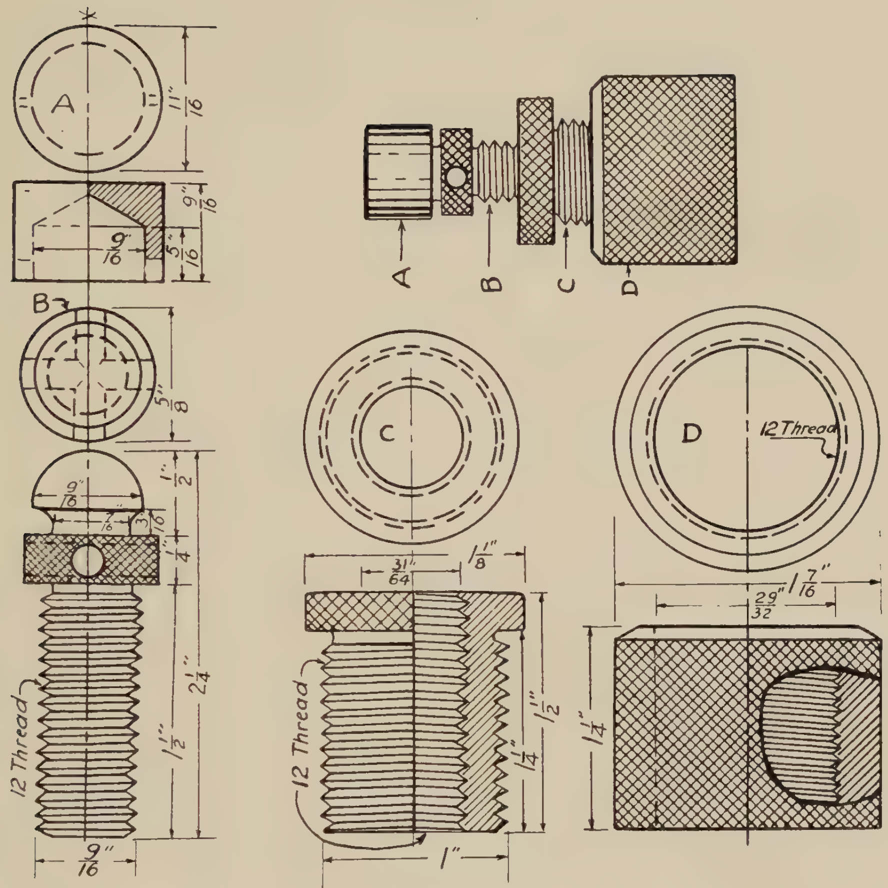
Object of Lesson: Ball turning; internal and external thread cutting; knurling.

Tools and Equipment: Lathe; chuck; drills; 9/16-in. tap; outside and inside thread tools; boring and knurling tools.

Materials Required: Round machine steel, for A and B, 3/4 by 3 in.; for C, 1 1/4 by 1 5/8 in.; for D, 1 1/2 by 1 1/2 in.

Procedure:

1. To make A and then B, prepare the stock and grip it in the lathe chuck.



DETAIL OF TELESCOPE JACK

2. Drill a 9/16-in. axial hole, 5/16 in. deep, face the end and turn it to 11/16 in. diameter.

3. Saw two slots, ¼ in. deep, diametrically across the end and at right angles to each other.

4. File and polish. Cut off A to a length of 9/16 in.

5. Center the stock for B, and mount it on the lathe centers.

6. Lay off, and cut the two neckings with a parting tool, 7/16 in. diameter, ¼ in. apart.

7. Turn both ends to 9/16 in., and face the ends.

8. Turn portion between the neckings to ⅝ in. and knurl. Drill two 3/16-in. holes at right angles through the knurled portion.

9. Prepare stock for C, and grip it in the lathe chuck. Let ½ in. protrude.

10. Face the end. Drill a 31/64-in. axial hole through it. Tap it with 9/16—12 threads.

11. Turn the end down to 1⅛ in., and knurl it.

12. Remount B on the lathe centers, and cut 9/16—12 threads to fit into C.

13. Screw C into position on B. Cut the necking on C, 29/32 in. in diameter.

14. Turn the threaded portion of C to 1 in., and cut the 1—12 threads. Face the end.

15. Prepare stock for D. Mount it in the lathe chuck. Face the end.

16. Drill a 29/32-in. hole. Prepare the inside thread tool, and set it.

17. Cut the inside thread in D, 1—12 threads, to fit well on the thread on C.

18. Chamfer the face edge of D. Screw D in position on C, which is on B.

19. Mount the three together on the lathe centers. Turn D to 1 7/16 in.

20. Knurl D, and face the end to length. Remove the work from the centers.

21. Reverse and mount the work in the lathe chuck. Put a card under the jaws.

22. With the three parts together, running true, turn the ball to fit into A.

23. Compress the lower edges of A around the ball of B, to tilt freely.

24. Finish and polish all parts to perfection. Then inspect it to see whether any improvements can be made.

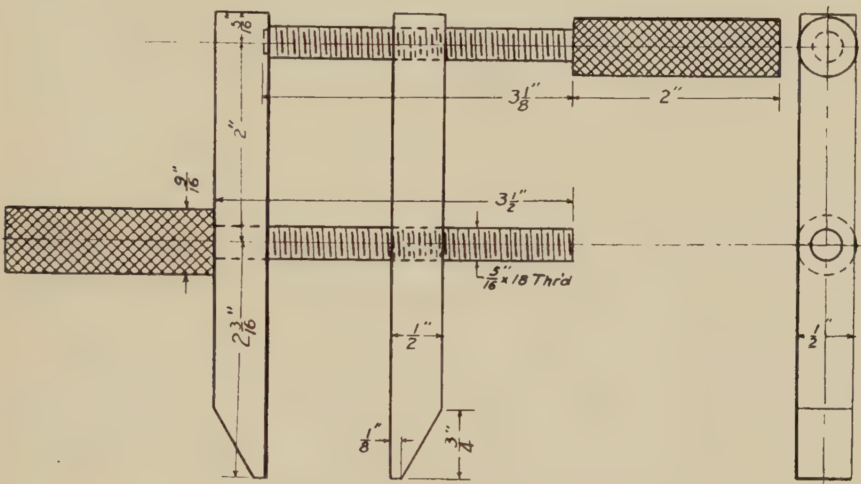
QUESTIONS

1. In sawing off stock with a hand hack saw, what precaution must be taken to make the cut square?
2. Is 1/16 in. enough to allow for finish on each end of the stock?
3. Should the allowance for finish be greater on large stock than on small?
4. In turning cylindrical work, is the stress on lathe centers greater in rotating large diameters than in small? Why?

Problem 63
MACHINIST'S CLAMP

Subject and Uses: Holding small pieces while drilling them, pressing parts together during a soldering operation, and clamping several pieces in fixed relation to produce duplicate articles, are some of the various jobs for which these clamps can be used. The clamps are readily adjusted by taking a handle in each hand and swinging one hand over the other until the desired opening is reached. Great pressure between the jaws is

produced when they are used as levers of the first class; that is, the end screw is turned to exert power, and the screw in the middle of the jaws acts as a fulcrum. On the other hand, when the end screw is held still, and power is exerted by turning the screw at the middle, the jaws act as levers of the third class.



DETAIL OF MACHINIST'S CLAMP

Object of Lesson: Cutting threads on slender spindles; knurling; tapping.

Tools and Equipment: Lathe; knurling and threading tools.

Materials Required: Machine steel for screws, ⅝ in. round, 10¾ in. long; for jaws, ½ in. square, 9¼ in. long.

Procedure:

1. To make the jaws, saw the square stock into two equal lengths and saw off triangular corners, as shown in the drawing.

2. On the inside of the jaws, draw a center line. Locate and prick-punch for holes, one 5/16 in. and the other 2 5/16 in. from the butt end.

3. Drill ¼-in. holes through one jaw, and tap them with a 5/16—18 thread tap.

4. Drill the other jaw at the end ¼ in. in diameter ⅛ in. deep, and at the middle, 21/64 in. diameter clear through. NOTE: Holes must be drilled exactly on the center line so that the stock on both sides of the hole is equal in thickness.

5. File the ends square and to the required shapes. Drawfile the jaws on all faces, and polish them bright with emery cloth and oil.

6. To make the screws, saw the stock in two lengths, one 5 9/16 in., the other 5 3/16 in., and center them accurately.

7. Turn the handles to size, square up the ends and knurl; use oil.

8. Put a collar of sheet copper between the dog and the knurled surface, turn the screw to 5/16 in. minus .005 in., square up the shoulder, and chamfer the end.

9. Cut the thread 18 pitch, to a running fit in the jaws, and smooth the surface. CAUTION: Take light cuts on the slender spindle, because as the thread gets deeper, the cutting surface becomes greater and the spindle diameter smaller.

10. Go over all parts, round off the ends, and dull the sharp edges to attain smoothness.

11. Caseharden all wearing parts by heating each piece red-hot, and quickly rub powdered potassium ferrocyanide on the surfaces. This puts a higher per cent of carbon into the steel surface. This changed surface shell, or "case," is thus in condition to be hardened. When the heating is done slowly, and is not brought beyond a bright red, the interior of the metal will, after hardening the "case," still retain its original toughness and strength.

12. Reheat all parts to a bright red, quench them in oil, and assemble.

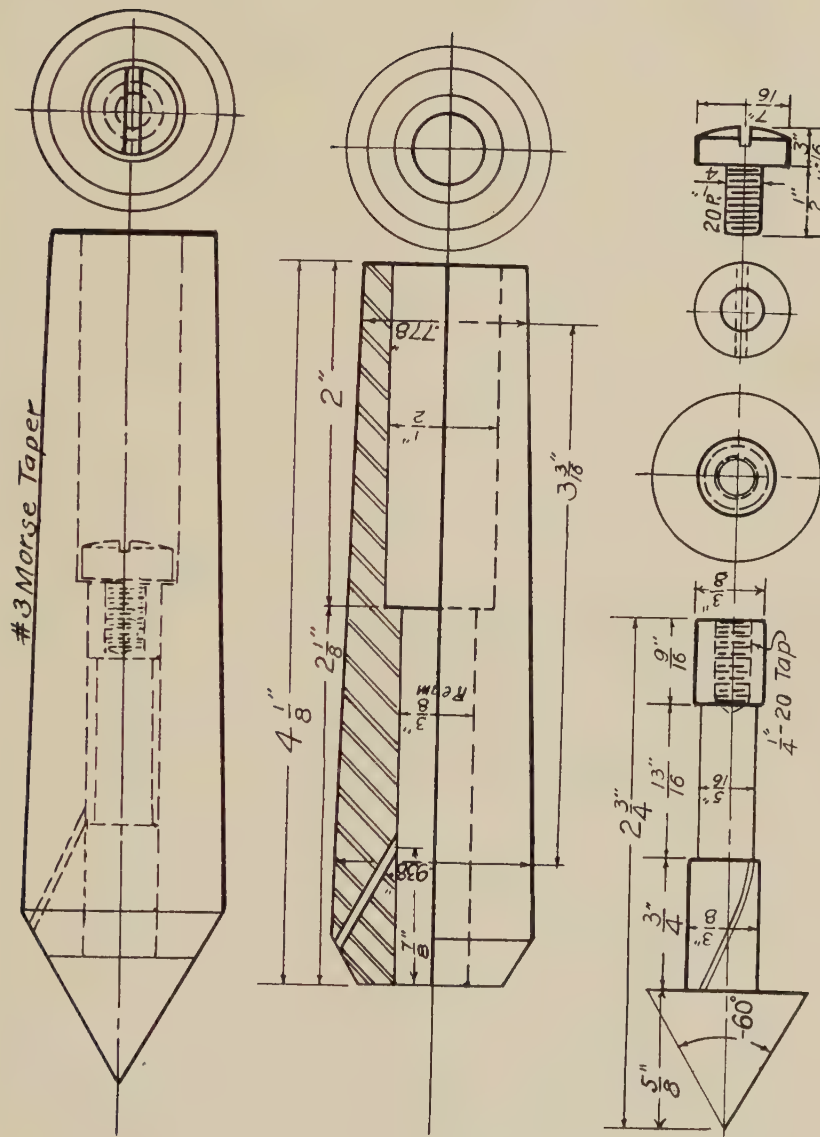
QUESTIONS

1. When turning the slender spindle, if the cut is too deep, in what direction will the work spring?
2. When the work is held in the clamp, how great is the pressure on it compared with the force exerted by the end screw?
3. How great is the pressure on the work compared with the tension on the screw in the middle of the jaw?
4. How would these conditions be affected if the screw at the middle were located 1 in. from the end screw? 3 in. from the end screw?
5. What is a lever of the second class? What is its mechanical advantage?

Problem 64

ANTIFRICTION TAIL CENTER

Subject and Uses: Many pieces of turned work would be perfect if it were not for the ugly large centers worn so badly by the tail center. This wear and disfigurement of work may be obviated by the use of the antifriction tail center. As this center turns with the work, it is possible to mount tubular and internal-threaded work, as well as other delicately finished pieces, on the centers without having them ground out of shape. The spindle on which the revolving center is supported has bearings at its ends, and the central portion, which is smaller, serves as an oil reservoir and lubricates all the bearing surfaces. A fillister-head screw, which fits into the inner end of the spindle, keeps the revolving center from coming off the taper shank that holds it. An oil hole is drilled in a sloping direction from the top of the shank down to the oil reservoir. The oil supply may thus be replenished at any time.



DETAIL OF ANTIFRICTION TAIL CENTER

Object of Lesson: Turning hollow center to taper; fitting rotating spindle; drilling small oil hole; cutting oil grooves.

Tools and Equipment: Lathe; chuck; drills; tap; countersink; file.

Materials Required: Round machine steel, 1 by 4½ in., for shank, and ½ by 1½ in., for screw; round tool steel, ¾ by 3¼ in., for spindle.

Procedure:

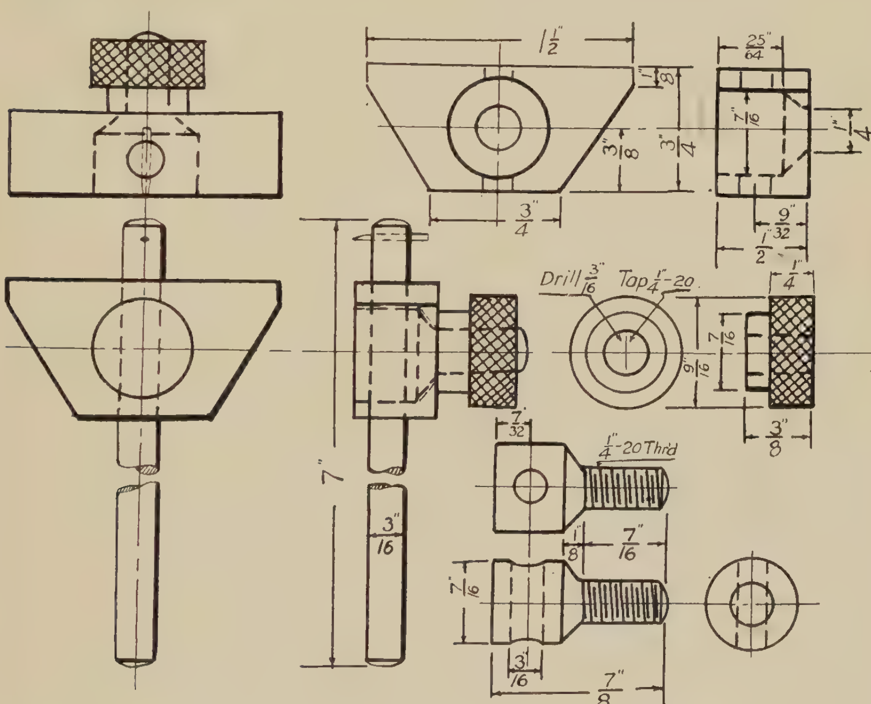
1. Prepare the stock for the shank, grip it in the lathe chuck, and drill a ¼-in. axial hole through it.
2. Follow with a 23/64-in. drill, and ream out to ⅜ in. Use oil, and ream at a low speed.
3. Countersink both ends, and mount the shank on the lathe centers.
4. Turn a No. 3 Morse taper, to fit the taper in the lathe.
5. Face the small end and file the shank smooth.
6. Turn the large end to 60 deg., and face the end.
7. Drill a ½-in. hole into the small end, and counterbore the bottom of the hole 2 in. deep.
8. Drill a ⅛-in. oil hole at the taper end of the large part of the shank, sloping down and inward to the point, ⅞ in. from the front end of the shank.
9. Center the stock for the spindle, turn the spindle to 13/32 in. for a length of 2⅛ in. and face the shoulder square.
10. Turn the central portion of the spindle to 5/16 in.
11. Reverse the work, and rough-turn the end to 60 deg.
12. Reverse the work. Finish-turn the spindle, file, and polish it to fit the hole in the shank.
13. Reverse the work, and finish-turn the center to align with the taper on the shank.
14. File the center to finish, and turn down the point to a perfect shape to the smallest possible diameter.
15. Drill an axial hole 9/16 in. deep, with a No. 15 drill, into the end of the spindle. Tap it for ¼—20 thread.
16. Grip the stock for the screw in the lathe chuck. Turn it to ¼ in., ½ in. long.
17. Face the shoulder and cut a ¼—20 thread to fit tight into the end of the spindle.
18. Turn up the screw head to 7/16 in. in diameter, and 3/16 in. thickness. Round off the head, and saw the slot.
19. Assemble the parts to a perfect running fit; then disassemble.
20. Harden the center. Clean, assemble, and oil the rotating parts.

QUESTIONS

1. In turning the 60-deg. center, to what angle should the compound rest be set?
2. Why is it important that the outside of the shank is turned concentric with the hole through it?
3. In what respect is a No. 3 Morse taper different from a No. 2? from a No. 4?
4. In hardening the center, why should it be heated slowly and evenly?

Problem 65
MARKING AND DEPTH GAUGE

Subject and Uses: This tool is used for measuring depths, and for marking parallel lines. The beam, which is movable on the spindle, may be clamped at any desired point, and thus make the setting permanent



DETAIL OF MARKING AND DEPTH GAUGE

and transferable. This also applies to the other end of the gauge, where a hardened steel barb pierces the spindle, making the tool suitable for marking fine but distinct lines on material, at any desired distance, within its limits, from the edge and parallel with it.

The clamping device is so arranged that the beam may be set without disturbing the accuracy of the measurement, and without marking the spindle. The spindle, when it is to be graduated, is given a thin coat of

paraffin and is clamped to a table, in direct line with a steel scale, 4 or 5 feet away. By means of a trammel, the graduations are transferred from the scale to the spindle, by scratching definite lines through the paraffin on the spindle. The lines on the spindle are started at the center of the barb, and are made like those on the scale. The etching is done by applying hydrochloric acid on the spindle graduations.

Object of Lesson: Making clamping device; special drilling; thread cutting; knurling.

Tools and Equipment: Lathe and tools; threading and knurling tools; tap and drills.

Materials Required: Machine steel for beam, ½ in. thick, ¾ in. wide, 1½ in. long; for clamp screw and thumb nut, ⅝ in. round, about 2½ in. long; for spindle, 3/16 in. round, 7⅛ in. long; for barb, No. 20 spring steel wire.

Procedure:

1. To make the beam, saw off a 1½-in. length from the ½ by ¾-in. stock.
2. At the center of one face, center-punch and drill a ¼-in. hole, clear through.
3. Follow this with a 7/16-in. drill, and stop when the point just comes through, leaving the stock in the bottom of the hole.
4. To make the clamping screw, grip the stock in the lathe chuck, so that it protrudes 1½ in., center, and support it on the tail center.
5. For a length of ⅞ in., turn the stock to 7/16 in. to fit into the hole in the beam.
6. Turn to ¼ in. for a distance of 7/16 in., making a sloping shoulder to fit against the bottom of the hole in the beam.
7. Cut a ¼—20 thread to fit into the screw gauge. Cut off the screw, ⅞ in. long.
8. Make a thumb nut from the same piece by drilling a 3/16-in. hole, ½ in. deep.
9. Steady the ¼—20 tap on the tail center, and turn it into the hole, carefully, applying oil. Avoid striking the bottom, because the tap is fragile.
10. Turn down the stock to 9/16 in. for ⅜ in., and knurl at the end for ¼ in.
11. With a parting tool, cut the necking to 7/16 in. in diameter, leaving the knurled portion ¼ in. long.
12. File off the sharp edges, and polish. Cut off the nut ⅜ in. long. Finish tapping.
13. Put a turn of No. 24 wire against the sloping shoulder of the

screw to allow for clamping the spindle, insert it into the hole in the beam, and tighten the nut on it.

14. Locate and center-punch the centers of both sides of the beam.

15. Drill halfway through from both sides with a ⅛-in. drill. Hold the beam on the center.

16. Run the 13/64-in. drill clear through the beam, and then remove the turn of wire from the beam hole.

17. Lay out the beam to the shape shown on the drawing, saw off the corners, and file all faces square and smooth. Polish the beam.

18. File the ends of the spindle to a hemispherical shape. Drill a hole for the barb, ⅛ in. from the end.

19. Sharpen the barb to a chisel point, and press it into place so it cuts a fine line.

20. Insert the spindle through the beam and clamp screw. Tighten the nut. File the head of clamp screw flush with the beam. Finish to a smooth surface.

21. Graduate the spindle to sixteenths of an inch. Polish all parts.

QUESTIONS

1. Is clearance required between the shoulder of the screw and the bottom of the hole in the beam? Why?
2. In what other relation can this type of clamping device be used?

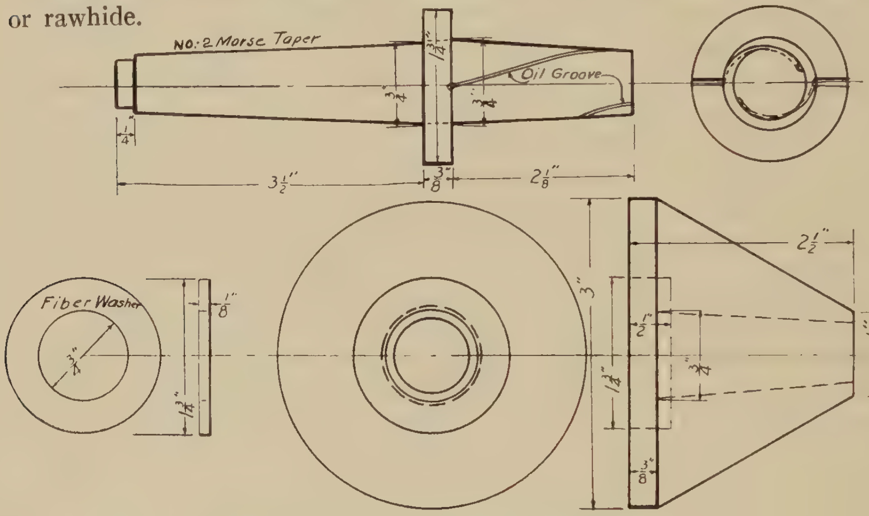
Problem 66
FRICTIONLESS PIPE CENTER

Subject and Uses: When a pipe is to be turned in the lathe, a special center, of a size large enough to fill the hole in the pipe, is needed. It is essential that this pipe center is so made that the taper part which fits into the pipe will turn on the shank which fits into the lathe spindle. This journal is made as nearly frictionless as practicable by the use of a taper bearing having spiral oil grooves, and by the use of a fiber washer against the shoulder, upon which the thrust is concentrated. The shank is turned to a No. 2 Morse taper on both ends. The large end of each taper should have a ¾-in. diameter. The steel shoulder on the shank is made as a separate collar, is shrunk on at the proper position, and is turned to size. However, it may be made with shank and shoulder from one solid piece, if preferred.

Object of Lesson: Turning, boring, and reaming taper; making fiber washer; cutting oil spiral grooves; making shrink fit; turning 60-deg. pipe center.

Tools and Equipment: Lathe; turning and boring tools; taper reamer; drills; file.

Materials Required: Round machine steel, for shank, ¾ by 6¼ in. long; for collar, 1 13/16 in. round stock by ½ in. thick; for center, 3⅛ in. diameter by 2⅝ in. long; for washer, 2 by 2 by ⅛ in. thick fiber, or rawhide.



DETAIL OF FRICTIONLESS PIPE CENTER

Procedure:

1. Prepare stock for the center, 3⅛ by 2⅝ in., and mount it in the lathe chuck.
2. Drill a ½-in. hole through the stock. Face the end.
3. Counterbore the end with a tool to 1¾ in. diameter, ½ in. deep.
4. Bore out the hole to taper, and ream it to size with the taper reamer.
5. Remove the work. Center the stock for the shank, and mount it on the lathe center.
6. Turn the shank to a No. 2 Morse taper at one end and to a taper which fits the pipe center at the other end.
7. File the shank, press it into the pipe center, and mount it on the lathe centers.
8. Set the compound rest to a 30-deg. angle with the lathe ways.
9. Turn the pipe center to an angle of 60 deg., by feeding with the compound rest.
10. Finish-turn, face the small end, and file and polish the pipe center all over.
11. Remove the pipe center from the shank.
12. Mount the lathe chuck, grip the stock for the collar, and drill a ⅝-in. hole through it.

13. Bore out the collar to .010 in. less than the diameter of the straight part of the shank.

14. Make a guide mark to show relative positions of collar and shank when they are reassembled. Remove the collar; heat it cherry red; slip the collar back into its original position. When the collar has turned black, quench it in water.

15. Grip the fiber in the chuck, drill a ⅝-in. hole through it, and ream it to fit on the shank.

16. With a narrow tool, cut an annular groove into the fiber to make the inclosed washer 1 25/32 in. diameter, and finish the face and edge square and to 1¾ in. before cutting the washer free from the surplus fiber ring in the chuck.

17. Mount the shank on the lathe centers, turn and face the collar to size.

18. Cut oil grooves radially on the collar face and spirally on the taper bearing for the pipe center. File smooth.

19. Mount the fiber washer on the shank. Fit the long end of the shank to the lathe spindle, and the other end to a running fit in the pipe center.

QUESTIONS

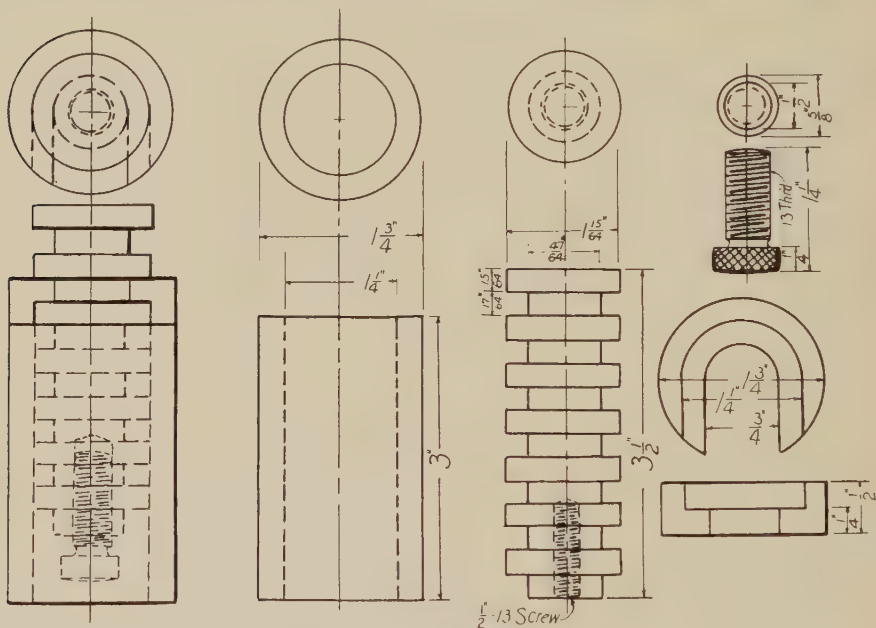
1. Why has this pipe center a 60-deg. angle?
2. Would a greater or smaller angle do as well? Why?
3. Why is the center to revolve with the pipe?
4. Why is a washer of rawhide or fiber interposed between the center and the steel washer?
5. Why is the oil groove on the arbor made in the form of a spiral?
6. In boring out the collar for a shrink fit, how much smaller than the arbor (or shank) should it be made?
7. If the diameter of a 1-in. collar increases .0000132 in. for 1 deg. F., what is the increase for 1,000 deg. (dull red)? for 1,600 deg. (cherry-red heat)? for 2,400 deg. (yellow heat)?

Problem 67
CLAMPING JACK

Subject and Uses: The assembled jack is made up of an outer sleeve, a core, a sliding collar, and an adjusting screw. It is adjusted to different heights by sliding the collar into the square grooves which are spaced regularly around the core. The collar rests on the top end of the sleeve, and fits around and supports the core. The desired height of the jack is readily attained by slipping the collar around the core at the particular groove that raises the core to the proper elevation above the sleeve. The height of the jack may be varied by successive steps of ¼ in., ranging from 3 in. to 6¾ in. The collar may be applied as a support of the core with the cup side either up or down, thus producing a difference in height

of ¼ in., and the screw in the end of the core is for closer adjustment.

When strapping work down on a planer, or on a milling or boring machine, or wherever work is to be clamped down, this jack will prove a great convenience as a support for the bolt-and-plate clamp. Sleeves of different heights may be made to be used in connection with the core and the collar. Heavy steam pipe, of suitable diameter, may be used as a substitute for the sleeve, when properly faced to the required length.



DETAIL OF CLAMPING JACK

Object of Lesson: Cutting and finishing annular grooves; making an open-side collar.

Tools and Equipment: Lathe; chuck; turning, parting, and facing tools; drills; hack saw; file.

Materials Required: Round machine steel, for sleeve and collar, 1⅞ by 3¾ in.; for core, 1⅜ by 3⅝ in.; for screw, ¾ by 1½ in.

Procedure:

1. To make the collar, prepare and grip the stock for the sleeve and the collar in the lathe chuck.

2. Face the end, start a true hole with a ¼-in. drill, and follow with a ¾-in. drill. Make the hole 1 in. deep.

3. Turn a counterbore recess ¼ in. deep with a 1¼-in. diameter. (See drawing.)

4. Take a finish cut on the outer surface, and smooth it with a file. Cut it off, making it ½ in. long.

5. Lay out and saw two parallel cuts to make a ¾-in. wide side opening in the collar.

6. Make two more cuts through the cup rim parallel with the previous two, 1¼ in. apart. Cut away the two portions flush with the cup bottom, and file all cut surfaces to a smooth finish.

7. To make the sleeve, drill with ¼-in., ¾-in., and 1¼-in. successive drill sizes through the stock, until a hole 1¼ in. in diameter has been obtained.

8. Face the ends of the sleeve square, and finish the outer surface with a fine cut.

9. File the surface smooth, and polish it with oil and emery.

10. To make the core, center the stock accurately, and mount it on the lathe centers.

11. Face the ends to the required length, and turn the piece all over to 1 15/64-in. diameter.

12. Lay out, center-punch, and with a parting tool, cut square grooves ¼ in. wide and ¾ in. in diameter, so that the collar will slip over the core, after the grooves are faced to a finish, ¼ in. apart. File and polish with oil and emery.

13. Drill a 13/32-in. hole into the small end of the core, 1¼ in. deep, and tap it with a ½—13 thread.

14. Make the screw to fit the hole in the core end. The screw part should be 1 in. long, and the head ¼ in. long with a ⅝-in. diameter and knurled.

15. Caseharden the screw, clean, and insert it in the core end for fine adjustments.

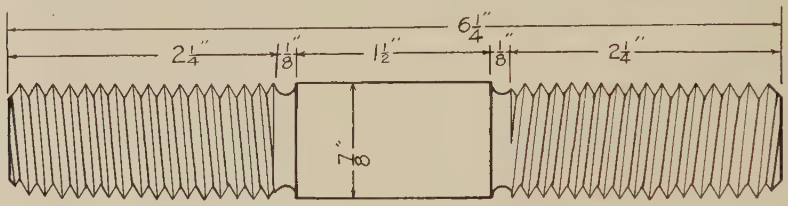
16. Fit the parts to work accurately and to assemble smoothly with any one of the parts inverted, as conditions may require. The large end of the core is up when used as a strap support, while the small end with the screw is up when work, requiring finer adjustments, is supported.

QUESTIONS

1. When cutting mild steel with a parting tool, what angle of rake is desirable? Is it advisable to grind the tool to that angle?
2. Should oil be applied when cutting mild steel? cast iron? brass?
3. Is it more economical to use a steam pipe for a sleeve than to bore out the solid stock? Why? Is it as strong? Is it as desirable? Why?

Problem 68
RIGHT- AND LEFT-HAND THREADS

Subject and Uses: Thread cutting is so generally a part of machine work, that every mechanic should master this art thoroughly. The type of screw shown here is made with a V-shape thread. The sides of the thread form an angle of 60 deg. It is important to have each side make an angle of 30 deg. with a line perpendicular to the axis. By using a thread gauge, the thread tool may readily be set to the correct angle.



DETAIL OF RIGHT- AND LEFT-HAND THREADS

The angle of the threading tool having been fixed by the thread-tool manufacturer, the top face of the tool is the only surface to be ground by the operator. This surface is to be ground at right angles to the front cutting edge of the tool. It should be noted that the way the top is ground affects the angle of the thread that it cuts. If the angle formed by the top face of the tool and the front edge is less than 90 deg., it will cut a thread that is less than 60 deg. If that angle is greater than 90 deg., it will cut a thread with an angle greater than 60 deg. This form of thread is of the same angle as the U. S. standard, and is used extensively on pipes, bolts, and other machine parts.

The left-hand thread is much like the right-hand thread. The difference is that for the left-hand thread the direction of the tumbler gears is reversed and the thread tool is started in a groove and fed toward the tailstock center. The right- and left-hand threads often are used in places where means are required for moving two machine parts together or apart simultaneously. Notable examples are the turnbuckle, the special vises, and the double turret-lathe heads.

Object of Lesson: Learning to cut right- and left-hand V threads.

Tools and Equipment: Lathe, preferably with compound toolrest; turning, facing, grooving, and threading tools; file.

Materials Required: One-inch machine steel, 6⅜ in. long.

Procedure:

1. Center the stock and mount it on the lathe centers.
2. Rough-turn the stock, leaving 1/32 in. for finish.
3. Face the ends, and chamfer the stock to 45 deg.

4. Lay off grooves to measure, and with a round-nose tool, cut grooves to the required depth, for the thread tool to start or finish cutting.

5. Calculate the number of teeth needed in the gear to go on the lead screw, and mount the gears on the lathe for the required pitch of the screw thread.

6. Set the threading tool on a level with the centers and to the exact angle.

7. Cut the right-hand thread by starting at the tail center and cutting as far as the first groove. Study the lead-screw split-nut clamp mechanism thoroughly.

8. Continue thread cutting, and adjust carefully the increase of the depth of the cut to correspond with the constantly increasing area of the cut. Oil must be applied as each cut is taken.

9. As the required depth is approached, the sides of the threads must be cut so that they are left smooth, and the work should be tested with some standard nut to ascertain how much more stock is to be removed.

10. To obtain a smooth thread surface more readily, the compound toolrest may be set over 60 deg. with the centers, and used when the tool must be advanced as the depth of the cut increases. The increase in the cut will then be taken off on one side of the groove instead of on two, and as a result the cutting will be smoother.

11. Finish the cut to size by allowing the tool barely to scrape against the surface. The right-hand thread is now complete.

12. Fasten two nuts on the finished thread, lock them against each other securely, and on one nut fasten a clamp dog. Mount the work on centers.

13. Reverse the direction of the lead screw by means of tumbler gears. Start threading with the tool at the other groove. Lock the lead-screw nut and run the tool toward the tail center.

14. Practice these manipulations several times, to acquire familiarity with the mechanism, before any accurate cutting is done.

15. Begin cutting the thread, taking a fairly heavy cut. The depth of the cut should be gradually decreased as the depth of the thread increases.

16. Finish the thread to exact size, and to a perfectly smooth surface.

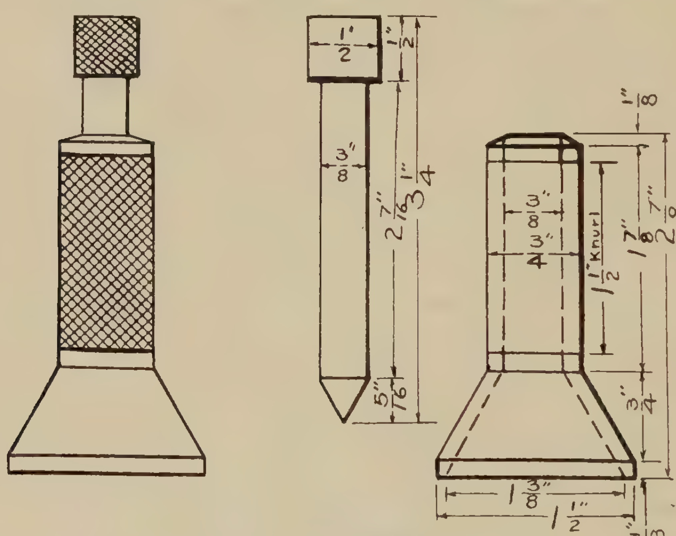
QUESTIONS

1. Is there any resemblance between a wedge and a screw thread?
2. What is the use of a wedge?
3. What is meant by the slope of a wedge?
4. What determines it?
5. How do we determine the difference in steepness in road grades?
6. What is meant by the pitch of a thread?

7. Why does a small cylinder require a screw of small pitch?
8. How does a screw serve as a mechanical device for multiplying force?
9. This increase of force is gained at the expense of what?
10. How does cutting a thread double on the same circumference affect the pitch of the screw?
11. How is the strength of shafting affected by the depth of the thread?
12. Why is a thread sometimes cut double?

Problem 69
CUP CENTERING TOOL

Subject and Uses: This is an inverted, funnel-shaped device, with a plunger down the center, to locate the center on stock, varying in diameter from ⅜ in. to 1⅜ in. inclusive. A hammer blow on the plunger center-punches the stock preparatory to drilling and countersinking. When the stock is cut off square, with the edges free of burrs, this tool fits exactly on the work, centers accurately, and saves time.



DETAIL OF CUP CENTERING TOOL

Object of Lesson: External and internal taper turning.

Tools and Equipment: Lathe with chuck and tools; knurling tool; drills.

Materials Required: Round machine steel, 1½ by 3 in. long, for the cup; round tool steel, ½ by 3½ in. long, for the punch.

Procedure:

1. To make the cup, center the stock accurately, and mount it on the lathe centers.

2. Turn down one end to ¾ in. for exactly 2 in. long. Knurl and finish it. (See the drawing.)

3. Face the end, and round off the sharp edge. Reverse the work end for end. Put a sheet-brass collar around the finished surface before tightening down the lathe dog.

4. Make a small tin template to 150 deg. Turn the outside taper by working the lathe handles simultaneously. Set the flat-nose tool to the required angle to finish the taper.

5. Face the end, and finish all parts by filing and polishing.

6. Grip the shank in the lathe chuck, but place a card between the jaws and the knurled surface. True up the work to run exactly concentric.

7. Drill a 23/64-in. hole clear through, and ream it out to ⅜ in. Use oil.

8. Make a 60-deg. tin template. Turn out the taper cup, using the compound toolrest, set to a 30-deg. angle with the line of centers, and a short boring tool, and finish to the required angle. Smooth it with a straight-nose tool.

9. In making the punch, center both ends, shallow drill the end to be pointed, and mount it on the lathe centers.

10. Turn the punch to a running fit in the hole through the cup.

11. Square up the end and the shoulders. Knurl the handle.

12. Turn down the pointed end to 90 deg. Finish the taper smooth. Turn the fine point to finish before it breaks off.

13. Put the work in the lathe chuck, and file it to a sharp point.

14. Caseharden the inside of the cup, harden and temper the point of the punch to a straw color.

QUESTIONS

1. What is a compound rest on a lathe?
2. What other method could have been used in turning the taper on the cup center? Which method is better? Why?
3. In working tool steel, what qualities do you find?
4. When exposing a slender and pointed steel piece to a fire, how may it be kept from burning?
5. How is a tool tempered?

Problem 70
PLANER JACK

Subject and Uses: An adjustable support is a great convenience for supporting, leveling up, or holding work on a milling machine or a planer. It also is very effective in lifting or depressing, without side sway, because under the heaviest stresses the jack will stand, the base and the cap remain stationary, while the screw is being turned. The screw, which has a square nut with holes through it, may be turned either by a wrench or a steel pin. Being mounted on a ball-and-socket joint, the top of the cap adjusts itself to set flat against the weight which it supports.

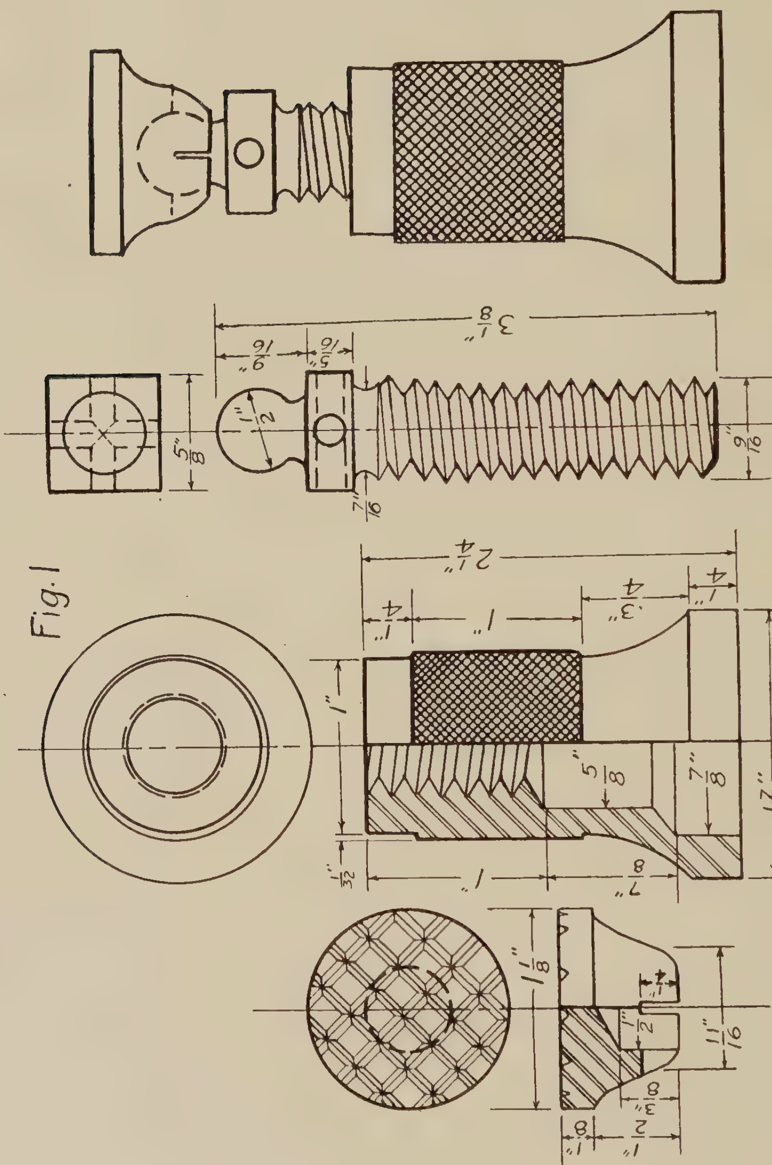


Fig. 1

DETAIL OF PLANER JACK

The directions given below apply to Figure 1, but they also will serve in general for the screw jack in Figure 2. The extension bases A and B are provided to extend the range of the planer jack described in Figure 2. The wedge-shaped base C also is a handy addition to fit on the base of the jack when such a part is desirable.

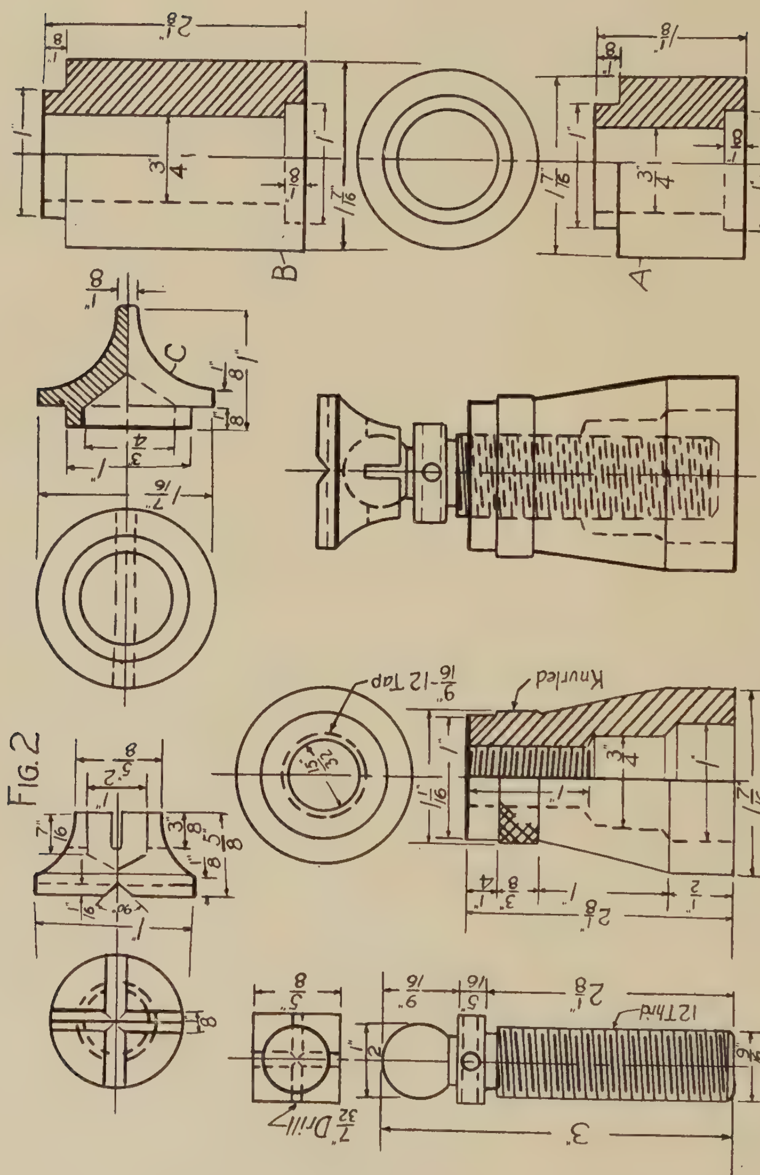
Object of Lesson: Making ball-and-socket joint; thread cutting; knurling; forming square recess; cramping.

Tools and Equipment: Lathe with chuck and tools; knurling and threading tools; taps and drills.

Materials Required: Machine steel, for Figure 1, for base and cap, 1½ in. round by 3¼ in.; for screw, 1 in. round by 3¼ in.; for Figure 2, for base and cap of jack, 1½ in. round by 3 in.; for screw, 1 in. round by 3¼ in.; for extension bases, A, B, and C, 1½ in. round by 4¾ in.

Procedure:

1. To begin making the cap, grip the stock in the chuck so it protrudes 1¼ in.
2. Drill a ½-in. hole, ⅜ in. deep into the end.
3. Turn down the end to the curve shown in the drawing.
4. Turn down the rim of the cap to 1⅞ in., file and polish it.
5. Make two saw cuts at right angles, diametrically across the hole, ¼ in. deep.
6. Cut off the cap with a parting tool, and file V grooves into the top surface, evenly spaced, at right angles to each other.
7. Start the base by drilling a ¼-in. hole through the stock remaining from the cap. Follow this with a ⅝-in. hole, 1¼ in. deep, and a ⅞-in. hole, ⅜ in. deep.
8. Face the end and finish; reverse the work end for end in the chuck, and grip it on the ¼-in. length.
9. Countersink the hole and steady the end on the tail center.
10. Turn down the shank to 1 1/16 in., and rough out the curved shoulder.
11. Knurl the shank, turn up the small shoulder, and finish the curved shoulder.
12. Face the end to dimension. File, and polish all over.
13. Run a 31/64-in. drill through the hole, and start a 9/16-in. taper tap, steadying it on the center.
14. Remove the work to a vise and finish the tapping with a plug tap.
15. To make the screw, center the stock and mount it on centers. Turn the shank down to 9/16 in. for the thread; cut the necking at the shoulder and chamfer the end.
16. Reverse the work end for end. Turn the ball to a spherical shape,



DETAIL OF PLANER JACK

to fit into the cap. Use a template with circular, concave side. Finish the ball, the neck, and the shoulder.

17. File or mill the ⅝-in. nut flat on four sides, and in the center of each side, drill a 3/16-in. hole.

18. Cut a smooth, 12-pitch thread on the shank. This is to fit into the base, so that there is no play.

19. Trim off the ball end for a smooth fit into the cap. Compress the four prongs of the cap around the ball to grip it, and yet allow the cap a swinging motion.

20. Caseharden the parts subjected to hard use and wear, and polish them bright.

21. To make extensions A, B, and C, grip the 1½ by 4¾-in. stock in the lathe chuck and let it project 2 in.

22. Face the end and finish turn to 1 7/16 in. for a distance of 1½ in.

23. Reverse the work and grip the turned part in the chuck for 1¼ in. Center the end, and steady the work on the tail center.

24. Finish-turn the remaining length to 1 7/16 in.

25. Drill a ⅜-in. axial hole and follow with a ¾-in. drill to within ⅞ in. of the other end.

26. Remove the work to the bench vise and, on the solid end, shape the web on C with a hack saw and a file, to the shape shown in the drawing.

27. Insert the hollow end of the work in the chuck for 3 in. and cut a shoulder on C. Then finish and cut it off to length.

28. To make A, bore out a square recess, and face the end. Cut a shoulder 1 in. from the end, then finish and cut it off to length.

29. To make B, bore out a square recess, face, and finish the end.

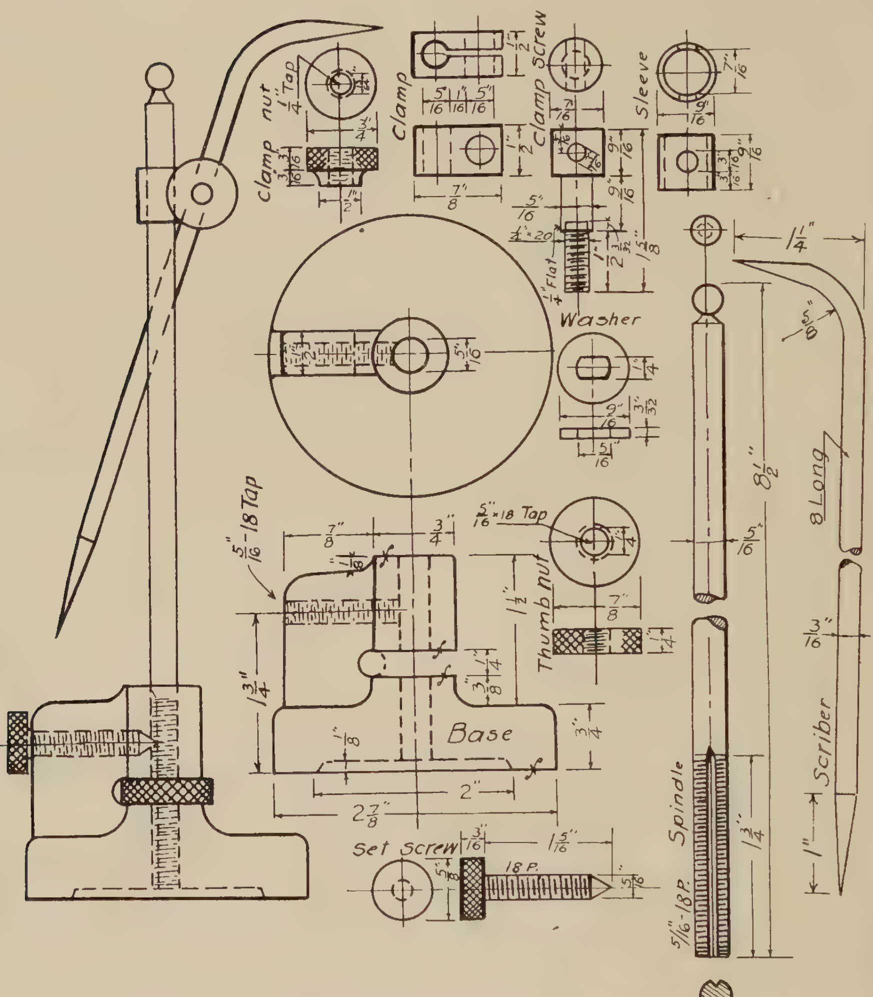
30. Reverse the stock in the chuck, turn the shoulder, and face the end to length; then finish. The 1-in. projections should make a running fit in the recesses.

QUESTIONS

1. How is the finished work gripped in the chuck without marring it?
2. Why use oil on tap, threading, and knurling tools?
3. Why start the tap by steadying it on the tail center?
4. Holding the tap against the center, why not tap the hole by power?
5. What precautions are required in holding a drill or a tap on the tail center, while using the power?

Problem 71
SURFACE GAUGE

Subject and Uses: This tool is composed of a base, supporting a vertical spindle which is adjustable in height by a thumb nut and prevented from turning by a pointed setscrew, which fits into a V slot.



DETAIL OF SURFACE GAUGE

cut into the spindle. Mounted on the spindle by an adjustable clamping device is the scriber. This may be set to any desired height and angle. The finer adjustment is done by the thumb nut in the base and the desired setting of the point is attained and may be made permanent by tightening the setscrew. This gauge is used for transferring measurements and drawing lines in laying out machine parts, jigs, fixtures, and other appliances. It is also much used in leveling work on the planer.

Object of Lesson: Making, fitting, and assembling small metal parts accurately.

Tools and Equipment: Lathe; thread-cutting and knurling tools; drills, ¼-in. and 5/16-in. taps.

Materials Required: Cast-iron base; 5/16 in. round by 9 in. machine steel for spindle; 3/16 by 8½ in. steel scriber; 1 in. round by 6 in. machine steel for thumb nuts, setscrew, clamp nut, washer and sleeve; ½ in. square by 1 in. machine steel for clamp; ½ in. round by 1¾ in. for clamp screw.

Procedure:

1. Make the base pattern, and have the casting molded and ready for machining.
2. Grip the base stem in the lathe chuck, true up and face the base rim. Remove the work.
3. Grip the base, with the finished face true to the chuck, and the stem running true.
4. Drill a 19/64-in. hole clear through, and ream it 5/16 in.
5. Face the top of the base.
6. Drill a ¼-in. hole for the setscrew, and tap it 5/16—18 thread.
7. Locate, drill, saw out, and file to size a ¼-in. opening, cut square across the stem of the base for the thumb nut, as shown in the drawing.
8. Center the spindle, and cut the thread a close fit to the screw gauge.
9. Cut a V groove by setting the V tool to cut sideways, and move the carriage by hand to plane the V groove. File smooth.
10. Turn the ball top on the spindle; file and polish to a bright finish.
11. Locate the holes in the clamp. Drill a 5/16-in. hole at right angles to the surface and split the clamp with a hack-saw cut.
12. To make the clamp nut, grip 1-in. round steel in a chuck, drill 13/64 in., and tap ¼—20 thread. Turn the nut ¾ in., and knurl. Turn the shoulder ½ in., face, polish, and cut off to ⅜-in. thickness.
13. Turn the thumb nut ⅞ in., and knurl. Drill ¼ in., and tap 5/16—18 thread. Face, polish, and cut off the nut to fit the opening in the base.
14. Turn the washer 9/16 in., drill a ¼-in. hole, face, polish, and cut off to 3/32 in. File the hole to an elongated shape, 5/16 in. long, using a ¼-in. round file.
15. Turn the setscrew. Hold the screw in the chuck and on the tail center. Turn it to 5/16 in., and cut 18 threads per inch to fit the tapped hole in the base. Turn the head ⅝ in., and knurl. Make the point 60 deg. Polish, cut off, and then caseharden the screw.
16. Make the sleeve. Drill a 7/16-in. hole through the stock and then turn it to 9/16-in. diameter. Drill a 3/16-in. hole at right angles to the

axis for the scriber. Face, and cut off the stock to measure 9/16 in. in length.

17. Make the clamp screw on the lathe centers. Center the stock. Turn the head to fit the sleeve. Drill a 3/16-in. hole, 5/16 in. from the end. Turn the shank 5/16 in. Face the shoulder and the end of the head so that the sleeve projects 1/32 in. over the shoulder, with the scriber inserted. Turn the shank to ¼ in. diameter and cut the thread to fit the clamp nut with ¼—20 thread. File the flats on the shank to fit the ¼ by 5/16-in. hole in the washer.

18. Make the scriber from good 3/16-in. steel wire. File it to a point, bend it to shape, polish, and caseharden it.

19. Fit all parts together so that they work easily. Enamel the base black.

20. Assemble the parts after they have been polished.

QUESTIONS

1. Why must the clamp have a tight fit on the spindle?
2. How may the washer and the sleeve be fitted against the clamp to attain maximum friction?
3. By what other clamping arrangement may the spindle and the scriber be tightened with one nut?
4. Why should the angle of the V groove in the spindle be slightly greater than that of the setscrew point?

Problem 72

BALL-CRANK AND HANDLE TURNING

Subject and Uses: The type of handle described here is quite universally used in manipulating moving parts on metal-working machines. Its proportions are so definitely established, that its form and the method of construction deserve close study. The three balls are spherical in shape and the spindle connecting them is conical. Here is an interesting example of how the circular cutting plane is common to both the sphere and the intersecting cone. It is advisable to make concave circular templates to use when turning up the balls on the crank and the curves on the handle. The templates are carefully drawn on stiff cardboard, and are cut to shape with a sharp-pointed knife. The curved forms are turned up by using a keen, round-nose tool, and by manipulating a feed handle with each hand.

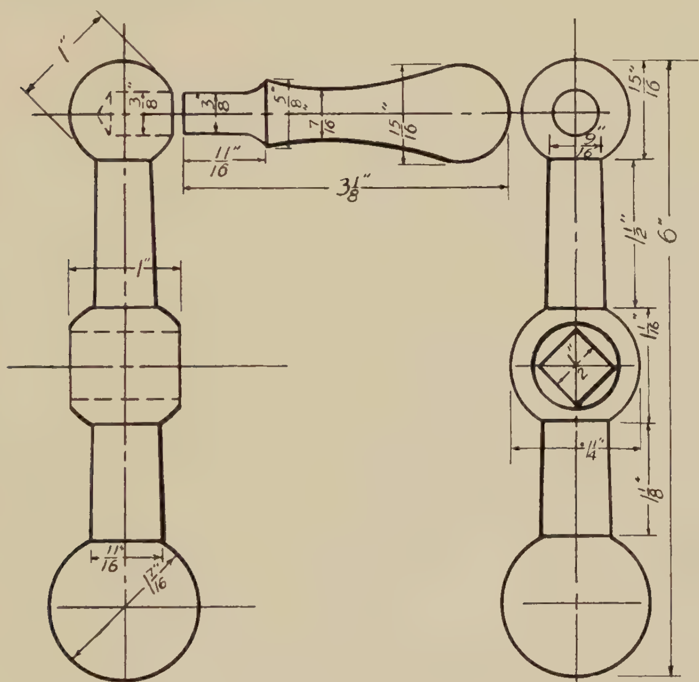
Object of Lesson: Turning spheres; drilling hole through sphere center; filing square hole; turning curved-contour handle.

Tools and Equipment: Lathe and tools; drills; files.

Materials Required: Round machine steel: for crank, 1½ by 6¼ in.; for handle, 1 by 3¼ in.

Procedure:

1. Cut off the proper length of stock for the crank, and center it.
2. Mount the stock on lathe centers and rough-turn it to 1 29/64 in.
3. Lay out, and with a center punch, mark sphere dimensions.
4. With a parting tool, make cuts outside of each ball, to a depth that allows finish on the conical portion.
5. Rough out the cylinder. Remember that heavy cuts will spring the stock.
6. Rough-turn the balls. Use a cardboard template, or one of tin.



DETAIL OF BALL-CRANK AND HANDLE TURNING

7. Finish turning the balls. Use a tool with a concave curve, set at different angles.
8. Set over the tailstock, and turn the conical portion to the required taper. File it to a finish.
9. Lay out two holes, and level the axis of the crank in a drill-press vise.
10. Drill a ½-in. hole through the center ball, and the hole in the small ball ¾ in. deep, with a ⅜-in. diameter.

11. File the center hole ½ in. square, with flats across the ends. Polish the whole bar.

12. Center the stock for the handle. Lay out, mark, and make cuts to measure at the principal points. Make a template.

13. Rough-turn the handle. Use a template.

14. Turn the small end to a press fit in the crank. Put brass under the dog on the small end.

15. Finish-turn the spherical end and the curved shank, with curved shoulders supporting the sharp crest, and file perfectly smooth.

16. Polish all parts in oil and emery to a good finish; then assemble.

QUESTIONS

1. In drilling the holes in the crank, why is the axis to be level?
2. Why should the axis of the holes intersect the axis of the crank?
3. Should the two holes be drilled parallel? Why?
4. By what method may they be made so?
5. In filing the hole in the center ball square, how does the drilled hole serve as guide?

Problem 73
GROOVED PULLEY

Subject and Uses: This pulley has 60-deg. grooves cut into the rim for a triangular belt. Where the transmission of only a small amount of power is required, where space is at a premium, and where efficient belt service is imperative, this kind of pulley is used. The chief merit of this type of drive lies in the increased amount of belt and pulley contact on pulleys narrower than flat pulleys, and in the security of the belt. This pulley has three grooves, but the wood pattern is turned with three steps so that the pulley surfaces are square, and the grooves are machined by cutting with a parting tool down the center, to the bottom of the groove. This is followed by a 60-deg. V tool with a round nose.

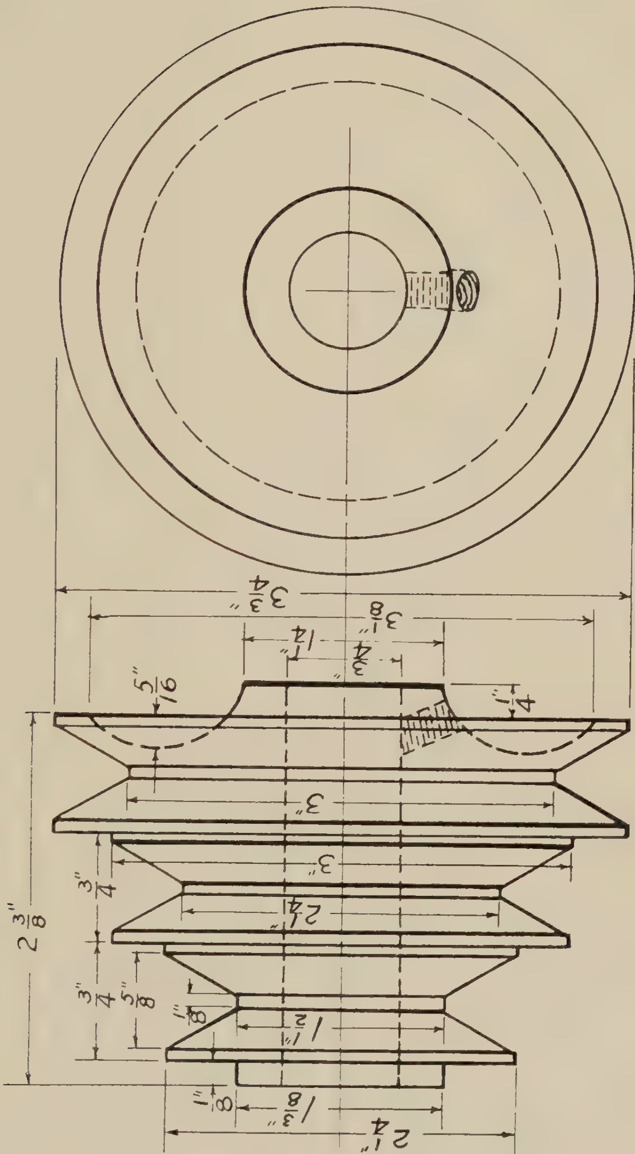
Object of Lesson: To make a three-step grooved pulley.

Tools and Equipment: Lathe; chuck; drills; reamer; ¾-in. mandrel; V tool; parting and turning tools; file.

Materials Required: Suitable casting.

Procedure:

1. Grip the casting in the lathe chuck. Rotate it, hold the chalk to mark the high spots, and readjust or tilt the casting until it runs true.
2. Start the drill, true, drill the hole 47/64 in., and ream it to ¾ in.
3. Oil the hole, press in the mandrel, and mount it on centers.
4. Rough-turn the hubs and the steps, allowing 1/32 in. for finish.
5. Rough out the faces, the shoulders, and the recess on the large end.
6. Finish-turn the hubs and the steps. Face the hubs, shoulders, and recess.



DETAIL OF GROOVED PULLEY

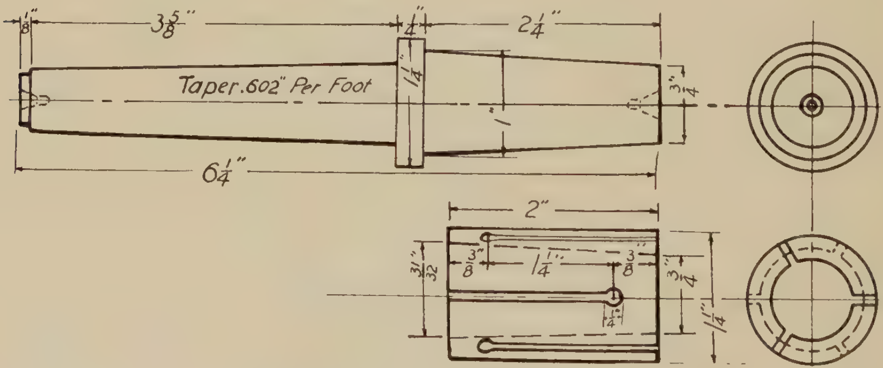
7. Cut the groove center to dimensions with a parting tool.
8. Finish the grooves with a round-nose, 60-deg. V tool.
9. With a file, dull all sharp edges, and polish the entire pulley with oil and emery.
10. Drill a ¼-in. hole through the hub at the large end, and tap it for a 5/16-in. headless setscrew.

QUESTIONS

1. Does a flat belt slip on the pulley more readily than a three-cornered belt?
2. Is a three-cornered belt more efficient than a round belt? Why?
3. Why is a flat belt used more generally than a round or a three-cornered belt?
4. Should the mandrel be pressed into that end of the hole where the reaming was started? Why?
5. Why should the length of a mandrel be in proportion to its diameter?

Problem 74
PLUG STUD ARBOR

Subject and Uses: A stud arbor is useful in turning small articles which require an arbor, as the work can be mounted and removed by rapping it with a mallet or a piece of babbitt. A set of sleeves, with the same bore and taper but having different external diameters, may be used on this arbor to accommodate work with various-size holes. The hole in the sleeve has the same rate of taper as the arbor, while the outside of the sleeve is cylindrical.



DETAIL OF PLUG STUD ARBOR

Subject of Lesson: Turning and boring taper; cutting slots in sleeve.
Tools and Equipment: Lathe; chuck; boring and turning tools; hack saw; drills; file.
Materials Required: Round machine steel, 1⅜ by 8¾ in. for arbor and sleeve.

Procedure:

1. Cut off stock for the sleeve and mount it in the lathe chuck.
2. Face the end and drill a 1/4-in. hole through the stock.
3. Drill a 1/2-in. hole through, and follow it with a 3/4-in. drill.
4. Set a compound toolrest to the required taper, and bore out the hole. The angle for a No. 2 Morse taper is about 1 deg. and 26 minutes with the ways of the lathe.
5. Finish-bore the hole to size and remove the work.
6. Center the stock for the arbor and mount it on the lathe centers.
7. Turn the whole length straight to 1 9/32 in.
8. Set over the tailstock to a taper of .602 in. per foot.
9. Turn the long end to a taper fit in the lathe spindle.
10. Turn the short end to fit to the taper in the sleeve.
11. Face the shoulders to length, and turn to size.
12. Reduce the butt end of the long taper, and face the ends. File and polish.
13. Insert the arbor into the lathe socket, and press the sleeve on the arbor.
14. Turn the sleeve to size and face the ends. File and polish.
15. Mark the sleeve with hair lines to locate holes 3/8 in. from each end.
16. Step off one of these circles into six equal parts, and punch-mark.
17. With a lathe tool, draw a horizontal line through each of these marks.
18. Center-punch and drill three 3/16-in. holes at each end, so that a hole comes on each of the six horizontal lines, 3/8 in. from the end, alternating between the ends for each successive hole.
19. With a hack saw, cut the six slots, beginning at the end farthest from the hole, and saw to the hole.
20. Remove all burrs, finish and polish with oil and emery cloth.

QUESTIONS

1. Where is the compound rest graduated? What is the unit of each space?
2. How may the number of degrees of the setting angle of the compound rest be calculated?
3. When the taper is given as the fraction of an inch per foot, how may that be associated with the tangent of the setting angle?
4. When the radius of the taper increases .3 in. per foot, may the tangent of the angle be found from the value 3/120, i.e., .025?
5. Looking up the "Table of Tangents," where .025 is the value of the tangent of the angle 1 deg. 26 min., is that the setting angle of the compound rest?

Problem 75

COMPENSATING SHAFT COUPLING

Subject and Uses: Some of the desirable features in a shaft coupling are that the twisting forces bear equally on opposite sides of the center of rotation, that there be a certain amount of flexibility in the contacts available, and that the coupling operates noiselessly. The shaft coupling shown here possesses these advantages. Moreover, it is self-aligning, and neutralizes incoming vibrations. The two discs, A and B, are of cast iron, and are machined all over. The ½-in. round pins, projecting from adjacent faces, are so placed that a continuous belt can be passed over and under these pins in alternate fashion, as is shown at F. It will be seen that by a number of loops in the belt, tightly stretched over the pins, the turning force is transmitted from one disc to the other. The steel pins D are pressed into holes drilled in disc B. Disc A, which is extra heavy, has holes drilled to make a push fit on pins C, and a slot cut into the periphery to such a depth that when the pins are in place they are exposed in the slot. It will be noticed that a groove is cut in pin C so that, when in position, this groove is right in line with the slot cut into the disc. The spring-wire ring E, sprung into the slot to bear in the grooves of the four pins, prevents them from moving endwise.

It is evident that by being able to remove these four outside pins, the work of forcing a tight rawhide belt into position is much facilitated.

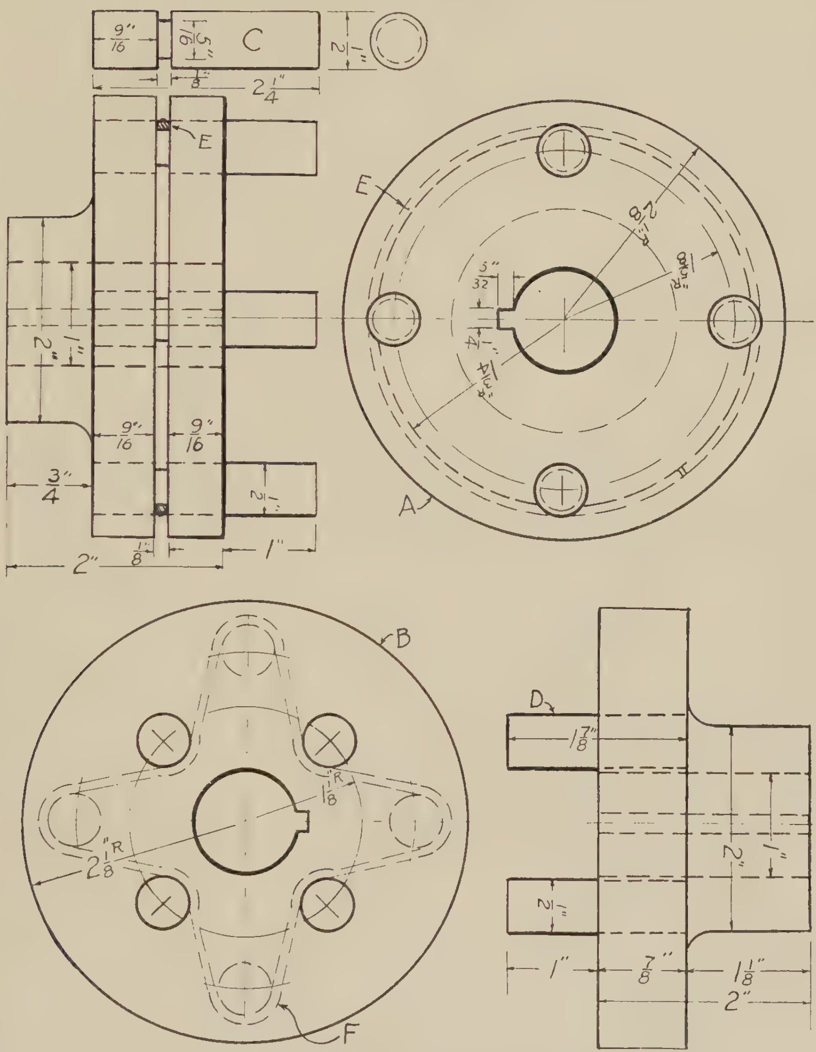
Object of Lesson: Study of action of flexible coupling; experience to be gained in its construction.

Tools and Equipment: Lathe and chuck; turning and boring tools; 1-in. reamer and mandrel; drill press and drills; ½-in. reamer; arbor press; cape chisel; hammer; files.

Materials Required: Iron castings prepared for A and B; ⅝ by 18 in. round machine steel, for pins; No. 12 spring wire 12 in. long, for ring; 1-in. rawhide belt, 15 in. long; 4 belt rivets and burrs.

Procedure:

1. Mount the casting in the lathe chuck, bore out the hole, and ream it to 1 in.
2. Press the casting on the mandrel and mount it on the lathe centers.
3. Rough-turn all over, allowing 1/32 in. for finish.
4. Finish-turn A and B all over, and file both castings smooth.
5. On the front face, cut a fine circle of 1⅛-in. radius on B, and 1⅝-in. radius on A.
6. Lay out, drill, and ream four equally spaced holes on these circles. (See the drawing.)



DETAIL OF COMPENSATING SHAFT COUPLING

7. With a ⅛-in. parting tool, cut a slot into the periphery of A, to 3½-in. diameter.

8. Turn up pins D, in pairs, on the lathe centers, to make them a press fit in B.

9. Turn up pins C, in pairs.

10. Finish the pins to push fit in the holes in A. Cut all pins in two, face the ends, and round off the sharp edges.

11. Lay out the keyway with a square and a scriber, cut to line with a cape chisel, and finish with a file.

12. Polish discs A and B, smooth and bright, with emery and oil.

13. Put the pins in position. Make the wire ring and spring it in place.

14. Rivet the belt together so that it will fit taut over the pins, and assemble the coupling.

QUESTIONS

1. Is a separate pattern necessary for each disc? Why?
2. Where are shaft couplings ordinarily used?
3. Would it be advisable to employ six pins in each disc instead of four?
4. How would the interaction between the two discs be affected if the shafts were out of line? If the belt were looped over only three of the pins instead of four? Why?

Problem 76
SCREW MANDREL

Subject and Uses: This mandrel is equipped with a taper shank that fits the lathe spindle, while the other end may be supported on the tail center. The mandrel is threaded along the greater part of its length and has two large washers mounted between the nut and the shoulder. Such appliances as buffing and emery wheels, saws, cutters, or cylindrical work which must be turned, may be mounted between these washers, and securely fastened, by tightening the nut. A mandrel of this kind is very handy in small shops, where many odd jobs are handled without the aid of special equipment.

Object of Lesson: Turning taper; threading mandrel and large taper washers; making the nut.

Tools and Equipment: Lathe and chuck; threading and other lathe tools.

Materials Required: Round machine steel: for mandrel 1 by 7½ in.; for nut, 1¼ by 1 in. long; two castings or steel stock for washers, ¾ by 2⅛ in.

Procedure:

1. Obtain castings, or steel stock for the washers.

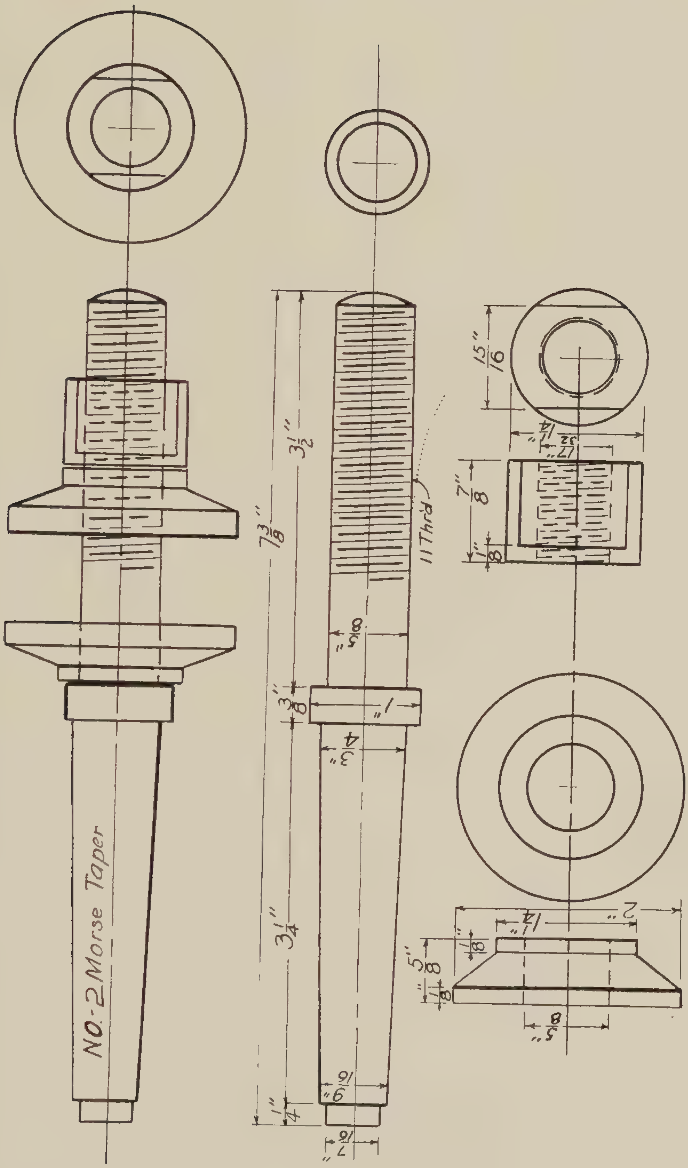
2. Grip the edge of the washer in the chuck with the straight face out and protruding ⅛ in.

3. Rough out the face and the edge, and finish smooth and to dimensions. Leave the shoulder at the edge square.

4. Reverse the washer in the chuck. Press the shoulder against the chuck jaws, and grip the finished portion.

5. Rough out the hub on the straight face and the sloping face. Leave 1/32 in. for finish.

6. Drill out the hole to 9/16 in. Turn the hole with an inside boring tool to within .010 in. of its size, and ream it to ⅝ in.



DETAIL OF SCREW MANDREL

7. Turn all parts to a smooth finish, and file. Polish with oil and emery cloth.

8. To make the nut, grip the stock in the chuck, face the end and drill a 17/32-in. hole.

9. Tap out the hole with 5/8—11 thread. Cut a fine line around the nut, 1/8 in. from one end, to mark the limit of the flats.

10. Reverse the work, face the end to dimension, and chamfer. File the flats parallel.

11. To make the mandrel, locate and center-punch the center of the stock, then drill and countersink it.

12. Mount the stock on the centers. Rough out the straight portion, leaving 1/32 in. for finish.

13. Reverse the work end for end. Set over the tailstock for a No. 2 Morse taper (.602 in. per foot); that is, 1/2 of 6/10 in. set-over per foot, or 3/10 in. per foot. In this case it is 7½/12, or 15/24 of 3/10, which equals 3/16 in. set-over of tailstock.

14. Turn the mandrel down to 9/16 in. on the small end of the taper. Leave the shoulder as shown.

15. Test the taper. Draw two heavy chalk lines along the opposite sides of the taper, and insert it into a standard socket. Turn the taper back and forth a little, and note the affect on the chalk lines. If the chalk is rubbed off the small end, then the taper must be increased.

16. Adjust the tailstock, and take a fine cut. Test the taper again, and finish to correct size.

17. Set the lathe straight. Finish the shoulders at the small end and at the middle of the mandrel.

18. File to a smooth finish and polish. Put brass under the dog at the taper end.

19. Reverse the work, and finish the portion to be threaded. Face and chamfer the end.

20. Cut 5/8—11 thread, and smooth to a close fit in the nut. File smooth and polish.

21. Inspect and test all parts for sizes and finish; then assemble.

QUESTIONS

1. In turning the taper, is it likely that too much stock may be removed before the correct taper is attained? How must this be prevented?
2. How may the correct taper be found before the stock is reduced to size?
3. Why is it not sufficient to set the tailstock over the calculated amount?
4. When turning the taper, should the cutting tool be set on a level with the center? Why?
5. If the tool is above or below center, how does that affect the taper?
6. What is the shape of the U. S. standard thread?

Problem 77
AUTO-RIM PUSH-PULL JACK

Subject and Uses: Most auto drivers have experienced the difficulty of removing tires from auto rims. Unless a jack is available with which the rim can be pulled free from the casing, it is a strenuous task to pull the tire off the rim to make the necessary repairs. Moreover, after the repair is made and the tire has been put back on the rim, the work of forcing the rim together to the required position without a tool suitable for the purpose, also is a hard job. The device described here makes tire removing and replacing an easy matter. It is light and convenient, durable and effective. An additional advantage to its lightness and durability, is that it may be folded together so compactly that it requires but little room in the car. The T iron used for the two sliding members may be readily obtained from dealers in bar iron. The pins are made from ¼-in. drill rod, and as the stress on them is great, the best quality of steel is required.

The jack operates as follows: The flanges of the two T bars, together, form a sliding contact. The guides AB hold them firmly together. Slots are cut through the web at B, and the guide-strip is put through the slot and bent around the two flanges at A. (See section AB in the drawing.) The handle H swings on pin K, and operates pawl C, which engages and pushes the notches in the T bar. Pawl D drops into a notch and grips the T bar so that a new hold may be taken by pawl C. The hooks R, when slipped over the tire rim, pull the rim off the seat and hold it while the tire is removed. The position of the pawls in the drawing shows this operation called the "pull." In order to "push" the rim back into its seat, the ends P are applied against the inner face of the rim, at points at right angles to the rim-joint. Pawl C is swung over so it points to the left, and pawl D is swung to point to the right. They are operated by the method indicated above. This jack is used for work on split rims.

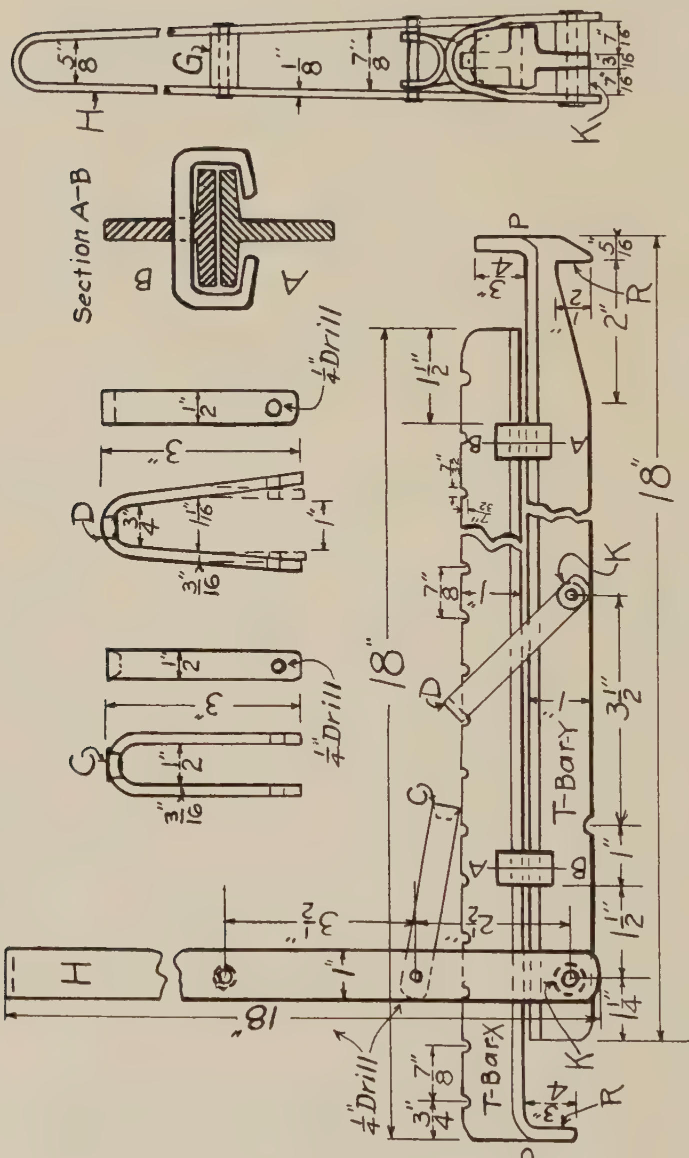
Object of Lesson: Bending, shaping, and riveting heavy cold metal; spacing and operating pawl mechanism.

Tools and Equipment: Vise; hack saw; drills and press; hammers; files.

Materials Required: For bars, 1 by 1-in. T bar, 38 in. long; for handle, ⅛ by 1-in. band iron, 37 in. long; for pawls C and D, each 3/16 by ½ by 6½ in.; for guides, each 3/16 by ½ by 3 in.; for four pins, ¼ by 6-in. drill rod; for spacing collars, ⅛-in. pipe, 3½ in. long.

Procedure:

1. Prepare bars X and Y to length; saw off a ¾-in. length of the



DETAIL OF AUTO-RIM PUSH-PULL JACK

web at P, and bend the flange at a right angle in a vise. Preheating is advisable.

2. Lay off notches in bar X and drill 7/32-in. holes at the edge of the web. Cut it out with a hack saw and file it to a right angle with the edges.

3. Lay out and drill three 3/16-in. holes for each guide slot at B, in X and Y; cut clear, and file the slots to fit 3/16 by ½-in. stock.

4. Prepare the stock for pawls C and D, and bend it at the middle around the round stock.

5. Prepare stock for the handle, and bend it in the middle over round stock.

6. Lay out and drill ¼-in. holes for pins, three in the handle, one in each of the pawls, and two in bar Y at KK.

7. In bar Y, cut out recess shown at R, and file it to shape.

8. From ⅛-in. pipe, saw off collars, 4 for pins KK 7/16 in. long, and 1 for pin G, ¾ in. long. File the ends square.

9. Prepare stock for two guides, round off the ends, and insert them through the slot in the bar at B. Grip the guide and the two bars together in a vise, and with a heavy hammer, bend the guide around the bar with flanges equal on both sides, as shown at section AB. This applies to the guide through bars X and Y. It is well to insert a piece of tin between the free bar and end flap of guide as it is being hammered down, to prevent the bar from sticking.

10. Take the handle H and insert the spacing collar at G, put the pin in place, and rivet it neatly.

11. Prepare pawl C. File the outer edge to an acute angle, shown at C, to fit into the notch in the bar. File the ends round, put the pawl in place in the handle, and insert and rivet the pin neatly so that the pawl swings freely.

12. File the ends of the handle semicircular, put it in place on the bar, slip a collar under the handle end and on each side of the web, shown at K, insert the pin, and rivet it to a strong head. The handle should swing clear to the left, over the end of bar X, and fold up along bar Y where a notch is filed for the pin through C.

13. File pawl D so that the inner edge is an acute angle to fit into the notch, to hold it only when there is pull on the pawl, and to slide out of the notch when the bar is being pushed by pawl C. It is well to hammer pawls C and D to increase their thickness at points where they rest on the notch, to prevent sticking in the notch.

14. File the ends of pawl D semicircular, and bend them to a bulging shape to fit with clearance over the bar flanges.

15. Put pawl D in place, slip the collars under the ends and each side of the web, insert the pin, and rivet it neatly without play.

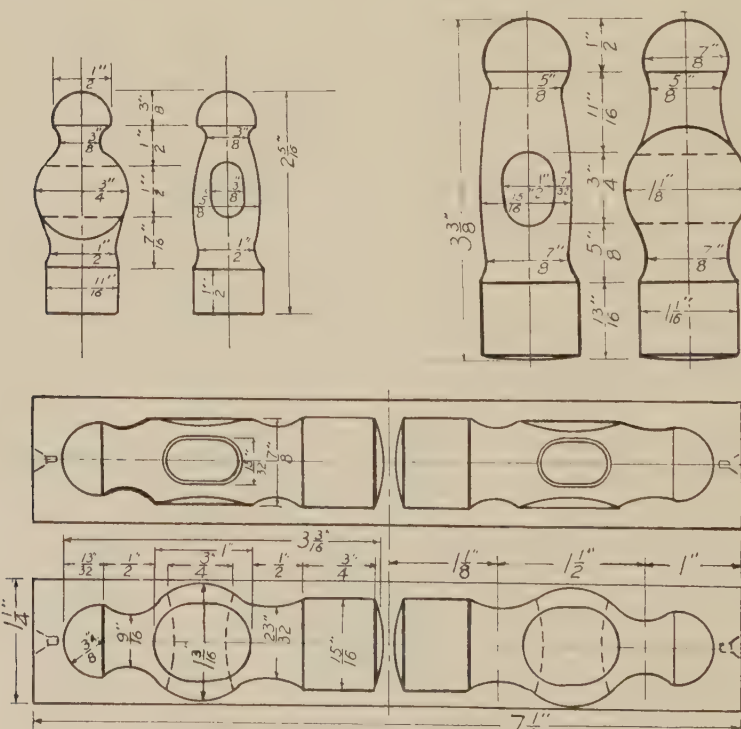
16. Limber up both pawls so that they swing freely and drop into places of their own weight; the bars also should slide freely. Go over all parts, removing sharp corners and edges, and see that the parts work well.

QUESTIONS

1. Describe six rolled bars of different section outlines?
2. What are some of the uses for each of these bars?
3. What factors limit the size to which each one of these types of rolled bars may be produced?
4. What influence does the use of structural steel have on the building industry?

Problem 78
HAMMER HEADS

Subject and Uses: The ball-peen hammer is used by machinists, toolmakers, structural ironworkers—anywhere where there is metal work to be done.



DETAIL OF HAMMER HEADS

The drawing shows three different sizes of hammer heads that also are slightly different in style. However, the method to be followed in making any one of them may be applied to all three.

Object of Lesson: Learning to turn curves of different kinds to dimensions; cutting the hole for the handle to shape and size; cutting and finishing the side contour to dimensions.

Tools and Equipment: Lathe and tools; drill press and drills; chisel; files.

Materials Required: Round tool steel, for two hammer heads, 1¼ by 7¼ in.

Procedure:

1. Cut off steel to proper size. Test for hardness. Anneal if necessary.
2. Center the stock.
3. Mount the stock on lathe centers, and take a light roughing cut all over.
4. Lay off and punch-mark distances for different parts. (See the drawing.)
5. Rough-turn the two concave curves on each head, allowing 1/32 in. for finishing.
6. Rough-turn the large end of the hammer, the central portion, and the ball end.
7. Lay out two holes on both sides of the head for the handle. Drill each hole slightly at a slant, so that the holes on the same side approach each other, as they go deeper, and stop halfway through.
8. With a chisel, cut the hole clear, and file it to shape for the handle.
9. In the shaper or with the chisel, cut away the stock to flatten the sides of the large central portion of the head, to an elliptically shaped cross section. File and polish it smooth.
10. Remount the stock in the lathe, finish-turn all over, and smooth to dimensions.
11. Run the parting tool down to ½ in., between heads, and finish the ends slightly oval, with a side tool.
12. Turn the ball end to a minimum diameter without breaking off the centers.
13. File all parts smooth, and polish them to a smooth finish.
14. Cut down between the heads, and finish, before they come apart.
15. Cut both ends of the head free, file them smooth, and polish.
16. Harden both ends of the head, and polish them. Make the handle of the proper size and shape. Fit the handle into place in the head, and lock it by driving in a steel wedge. Polish the handle and finish it with two coats of shellac.

QUESTIONS

1. In striking with a hammer, where is the center around which it swings?
2. Describe and give the uses for the following kinds of hammers: Cross-peen, claw, raising, jewelers', sledge, trip, steam, and pneumatic.
3. What causes edges of hammers to be broken?
4. Why should a mallet rather than a hammer be used in taking machines apart?

Problem 79

CENTERING HAND CHUCK

Subject and Uses: A little chuck is made so that by tightening the nut on the screw, the four jaws are compressed to firmly grip the countersink drill. The other end has a knurled shoulder for better hand grip. A 60-deg. taper recess also is bored axially into the end to fit on the lathe tail center. This tool is suitable for centering work in the chuck or in the steady rest. It is a great timesaver.

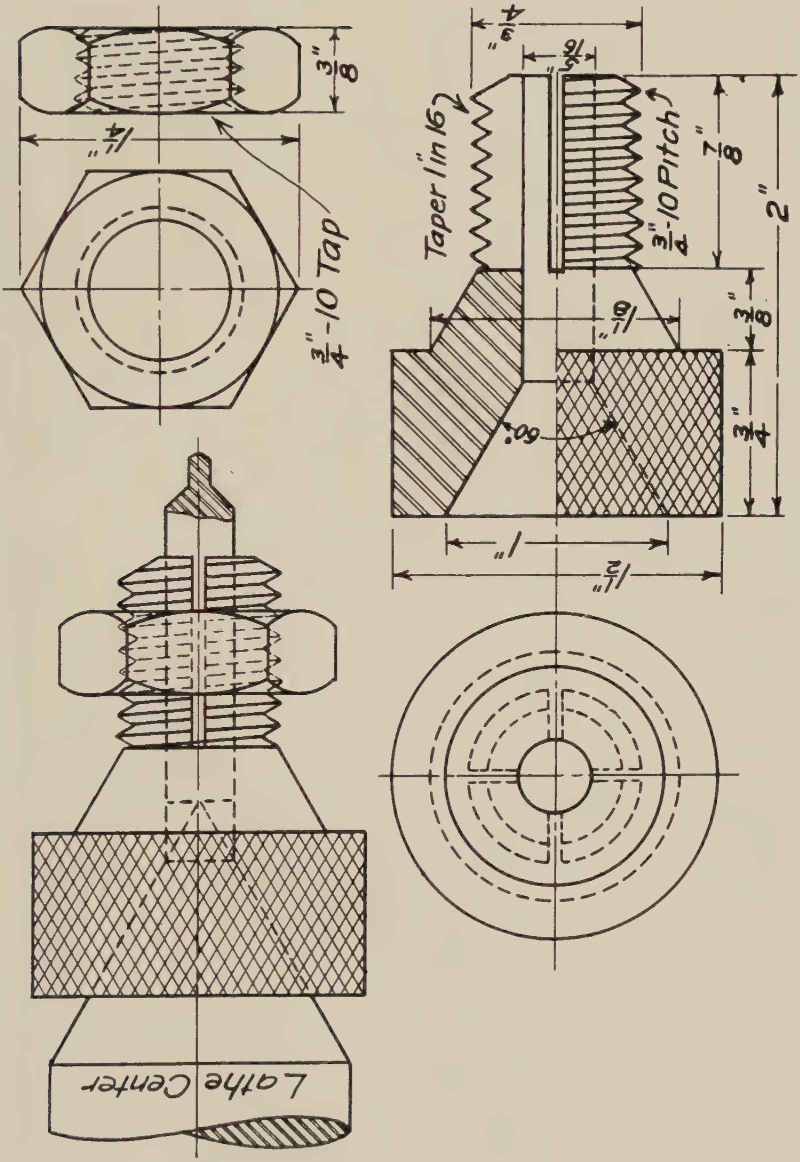
Object of Lesson: Making chamfered nut; turning 60-deg. recess; cutting taper threads; knurling and sawing slots.

Tools and Equipment: Lathe; chuck; small boring tool; knurling and threading tools; drills, ¾-in. taps; 5/16-in. reamer; hack saw; file.

Materials Required: For chuck and nut, 1½ by 2¾ in., round machine steel.

Procedure:

1. Cut the stock to length, grip it in the lathe chuck, and face the end.
2. Drill a ⅝-in. hole into the end, ¾ in. deep, for making the nut.
3. Tap out the hole with a ¾–10 thread tap, guiding and supporting it on the tail center.
4. Start the parting tool 7/16 in. from the end, and cut down to ⅞ in. in diameter.
5. Turn the nut to 1¼-in. diameter, and chamfer it on both sides.
6. Polish the nut, and cut it off. Step it off into six parts, file the flats, and finish it. Or, shape the flats in a milling machine.
7. To make the chuck, grip the stock to protrude 1¼ in. from the chuck, at the same end as before.
8. Drill a ¼-in. hole, 1¼ in. deep, and follow with a ½-in. drill, ¾ in. deep.
9. Set the compound toolrest to a 30-deg. angle, with the line between centers.
10. With a pointed tool, bore out a 60-deg. recess for the lathe center.
11. Face the end, and turn the scale off the outside. Knurl the end, and round off the edges.



DETAIL OF CENTERING HAND CHUCK

12. Reverse end for end. Shield the knurling, with sheet copper, from the chuck jaws.

13. Drill a 1/4-in. hole through the stock, and countersink lightly and steady on the center.

14. Turn the stock to the required shape, facing the shoulder and finishing the tapers.

15. Cut the thread to taper by cutting the thread deeper near the end to fit into the nut.

16. Finish the thread and the taper smooth, so that the nut will compress the screw as it advances.

17. Withdraw the tail center, drill a hole through the stock 19/64 in., and ream it to 5/16 in.

18. Remove the work. With a double blade in the hack saw, cut two slots at right angles, through the length of the threaded portion.

19. Remove all burrs with a small file. Finish the parts to exact shapes.

20. Polish all smooth surfaces, and caseharden the wearing parts. Clean all parts, and assemble.

QUESTIONS

1. How many of the foregoing required operations might be done on lathe centers instead of in the chuck?
2. When using the compound rest, is the power feed employed? Why?
3. In boring a hole, what determines the extent of the tool reach from the post?
4. Holding the work in the chuck, how is a taper thread cut?

Problem 80
TAP SOCKET WRENCH

Subject and Uses: This tool is made adjustable to fit and hold tight different sizes of small taps. The end of the sleeve cavity, being tapered, fits over a corresponding taper on the end of the stem. The stem is split by two saw cuts at right angles, and is compressible. A little wrench like this one, is especially adapted to holding fine taps which are quite fragile and require sensitive manipulation.

Object of Lesson: Making and tempering taper reamer; cutting inside thread; splitting stem.

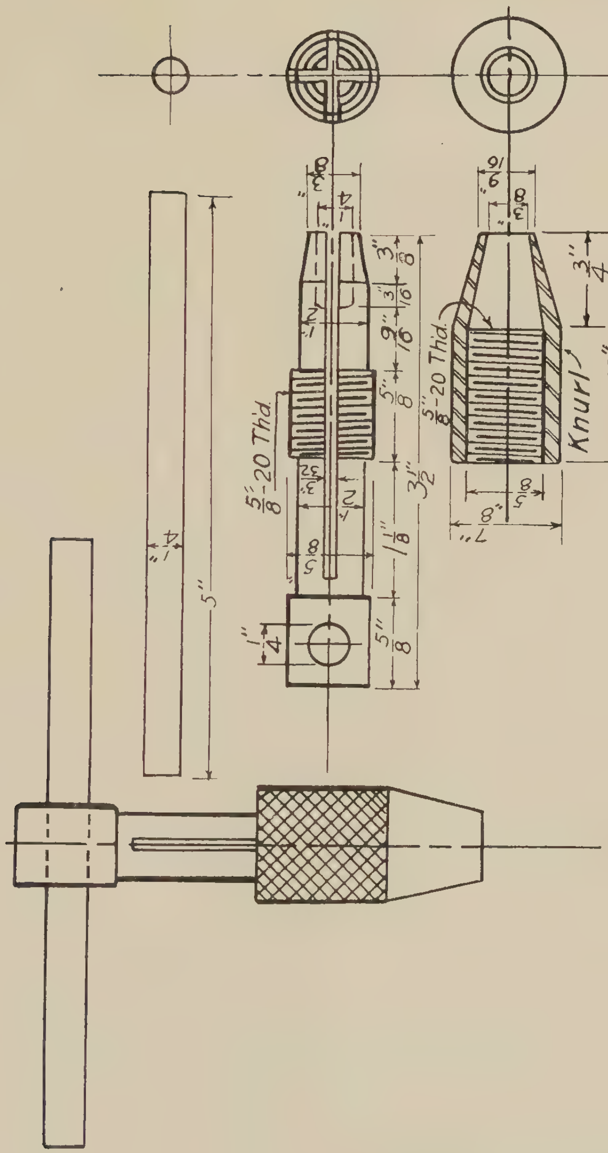
Tools and Equipment: Lathe; chuck; inside and outside thread tools; boring, knurling, and turning tools; hack saw; drills; files; flat reamer.

Materials Required: Round machine steel: For sleeve, 1 by 1 7/8 in.; for stem, 3/4 by 3 3/4 in.; for handle, 1/4 by 5 in.

Procedure:

1. To make the sleeve, grip the stock in the lathe chuck, face the end, and drill a 3/8-in. hole through the stock.

2. Drill a 1/2-in. hole 1 3/8 in. deep, and a 9/16-in. hole 1 1/8 in. deep.



DETAIL OF TAP SOCKET WRENCH

3. Make a 9/16-in. flat reamer; tapering for ¾ in. to 5/16 in., that is, 1 to 3.

4. Ream out the small end of the hole with a taper reamer.

5. With an inside thread tool, cut a ⅝—20 thread. Remove the sleeve.

6. Center the stock, mount on centers, and turn the stock for the stem to ⅝ in. diameter.

7. Turn the shanks to ½ in. (See the drawing.) Taper the end to ⅜ in. diameter for a length of ⅜ in.

8. Cut a ⅝—20 thread to fit into the sleeve.

9. Screw the sleeve on the stem, and turn it to shape.

10. Knurl the straight portion. Face the ends and polish the sleeve and the stem.

11. Remove the sleeve. Locate and drill a ¼-in. hole for the handle through the stem.

12. Drill a ¼-in. axial hole into the small end of the stem, 9/16 in. deep.

13. Draw four lines along the stem, spaced ¼ turn, as marks for saw cuts.

14. Mount two blades in the hack-saw frame. Start at the small end of the stem, and make two saw cuts at right angles, 2¾ in. deep.

15. Round off the ends and finish the handle; then press it into its place in the stem.

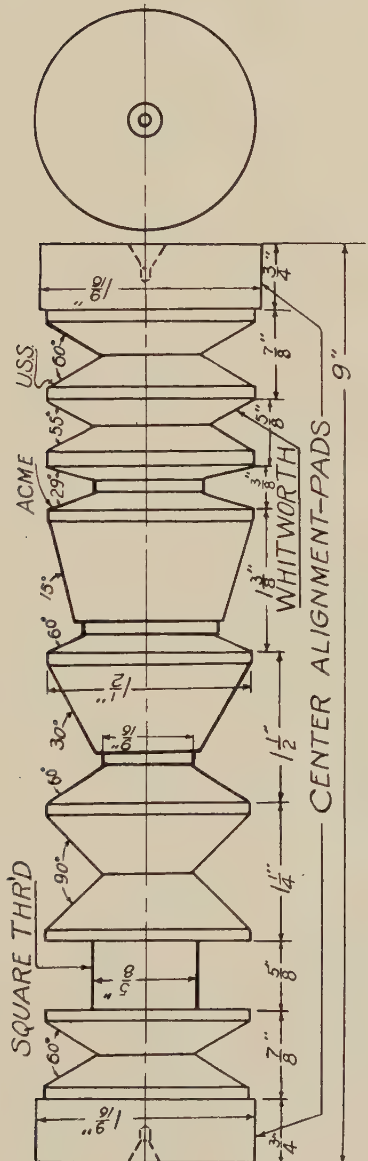
QUESTIONS

1. In making hack-saw cuts, following two lines, is it helpful in guiding the blade to tilt it to a small angle with the surface, and saw along the line, first on one side, then on the other?
2. Why are two blades used in slotting the stem?
3. In making the flat reamer, should it be turned on lathe centers before filing a clearance on the cutting edges?
4. To what color should the reamer be tempered?

Problem 81

LATHE-TOOL SETTING GAUGE

Subject and Uses: This tool is a great convenience to the mechanic who has much threading and work of a similar nature to do on the lathe. As a turning job, it affords a splendid opportunity to become familiar with setting the compound toolrest to various angles, and with the turning of different shapes and sizes. The ends are finished to equal diameters, so that the alignment of the lathe centers may be tested by checking the position of each end with the lathe tool against a strip of tissue paper. The V groove is used for setting large threading tools. The square groove is used for setting and testing square threading tools for the helical angle, lead, and squareness. The other grooves are for chamfering-tool setting,



DETAIL OF LATHE-TOOL SETTING GAUGE

for turning lathe centers, 15-deg. taper, Acme and Whitworth threading tools, and U. S. standard.

A good quality of steel should be used, and its finish should be as near perfect as possible both as to shape and smoothness.

Object of Lesson: Setting of compound toolrest; turning standard angle grooves.

Tools and Equipment: Lathe with compound toolrest; parting and pointed turning tools.

Materials Required: Tool steel, 1⅝ in. diameter, 9⅛ in. long.

Procedure:

1. Locate the centers accurately in the stock; drill and countersink the ends.
2. Face the ends, and polish the ends and the centers.
3. Take a small roughing cut the full length.
4. Locate the grooves to exact measurement, and mark their edges with light punch marks.
5. Make the cuts to the bottom of the shallow grooves with a parting tool.
6. Rough out all grooves, leaving 1/32 in. for a finish cut. Take light cuts in the deep grooves to avoid springing the work.
7. Set the compound toolrest and cut the grooves to the required angles. The tool must be set on a level with the lathe centers.
8. Turn the square groove and face the shoulders.
9. Turn the flats at the ends to equal diameters, 1 9/16 in.
10. Turn all intermediate shoulders so they will be 1/16 in. less in diameter than the ends.
11. File all surfaces lightly with a dead-smooth file without altering the perfect shape.
12. Polish with fine emery cloth and oil.

QUESTIONS

1. Through what angle is the compound rest turned in setting it for an angle of 15 deg. with the axis of the work?
2. When checking the lathe-center alignment, why is a strip of tissue paper slipped between the tool edge and the gauge point?
3. What does it indicate if paper slipped between the tool and the gauge, rubs at the tail center, but slides free at the live center?
4. In turning taper, how is the angle affected when the tool is set above the centers?
5. Is that equally true when using the compound rest? Why?
6. Does it apply when using the taper attachment? Why?

Problem 82

MACHINIST'S HAMMER WITH METAL HANDLE

Subject and Uses: This hammer is so designed that it can be turned up in the lathe, and yet have the rare property of being well balanced. The metal handle is screwed into the head securely, and has a knurled handle which is hollowed to lessen its weight. A threaded cap is used to cover and finish off the end of the handle. The space in the handle is a handy place to keep small drills, fine punches, etc. A small screw driver may be fitted into the cap.

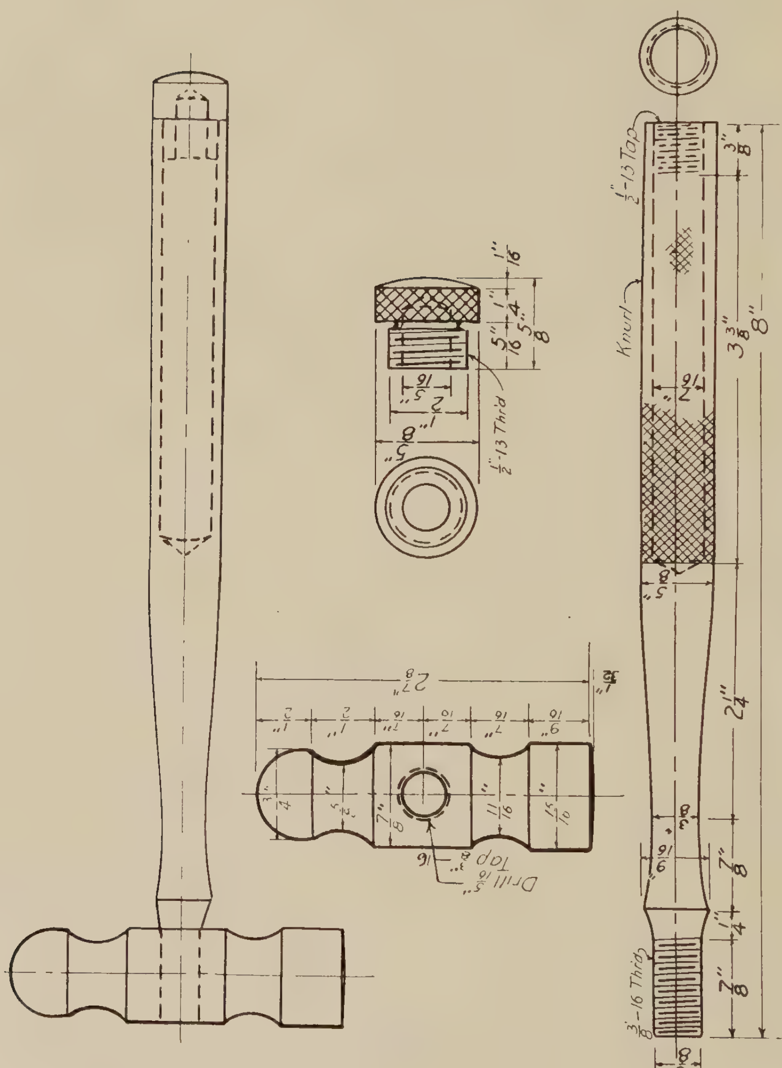
Object of Lesson: Complex curved contour turning.

Tools and Equipment: Lathe; knurling and thread tools; drills; 3/8-in. and 1/2-in. taps; turning tools.

Materials Required: Tool steel, for head, 1 in. round by 3 in. long; for handle and cap, 3/4 by 9-in. machine steel of good quality.

Procedure:

1. Cut off steel for the hammer head 3 in. long, and square it.
2. Grip the stock in the lathe chuck, letting it protrude 1 5/8 in.
3. Face the end, and rough-turn to 61/64 in. up to the chuck jaws.
4. Turn the circular groove to the shape and size shown in the drawing.
5. Finish-face the end with a slight convex.
6. Finish-turn to 15/16 in. up to the chuck jaws.
7. Reverse the work end for end. Grip the whole finished length true.
8. Rough-turn to 57/64 in. up to the chuck jaws.
9. Face the end to length, 2 29/32 in. from the other end.
10. Turn a 5/8-in. diameter curved groove in the required location.
11. Using a template, turn the ball peen to size, and spherical in shape.
12. Loosen the work in the chuck, move it out 3/4 in., and grip it to run true.
13. Turn the middle of the head to size 57/64 in., and finish to 7/8 in.
14. Lay out the hole for the handle with a surface gauge, on both sides of the head.
15. Center-punch and drill from both sides to 5/16 in., and tap 3/8—16 thread. Use oil.
16. Polish the head to a perfect finish; then harden and temper it.
17. Center the stock for the cap and the handle accurately, and mount it on the lathe centers.
18. Rough-turn the stock to 21/32 in. for 4 1/2 in. Finish to 5/8 in., and knurl. Use oil.
19. Turn the end down to a 1/2-in. square shoulder, and cut the necking 7/16 in.



DETAIL OF MACHINIST'S HAMMER WITH METAL HANDLE

20. Cut the thread ½—13, to fit the thread gauge. Reverse the work, end for end.

21. Put a copper collar under the lathe dog and rough out the stock.

22. Finish turning the reverse-curve handle contour to dimensions.

23. Turn down to ⅜ in. for ⅞ in., and round off the curved shoulder. (See the drawing.)

24. Cut ⅜—16 thread to fit close in the head; finish, and polish it bright.

25. Grip the knurled part in the chuck with the cap end protruding 1¼ in., and drill a 5/16-in. hole 7/16 in. deep.

26. Cut off the cap to length, leaving stock to finish the end convex.

27. Drill a ¼-in. hole into the end of the handle; true the hole, and follow with a 7/16-in. drill, 3¾ in. deep.

28. Tap the hole ½—13 thread for ⅜ in., and face the end.

29. Screw the cap in place, and finish the end convex and smooth.

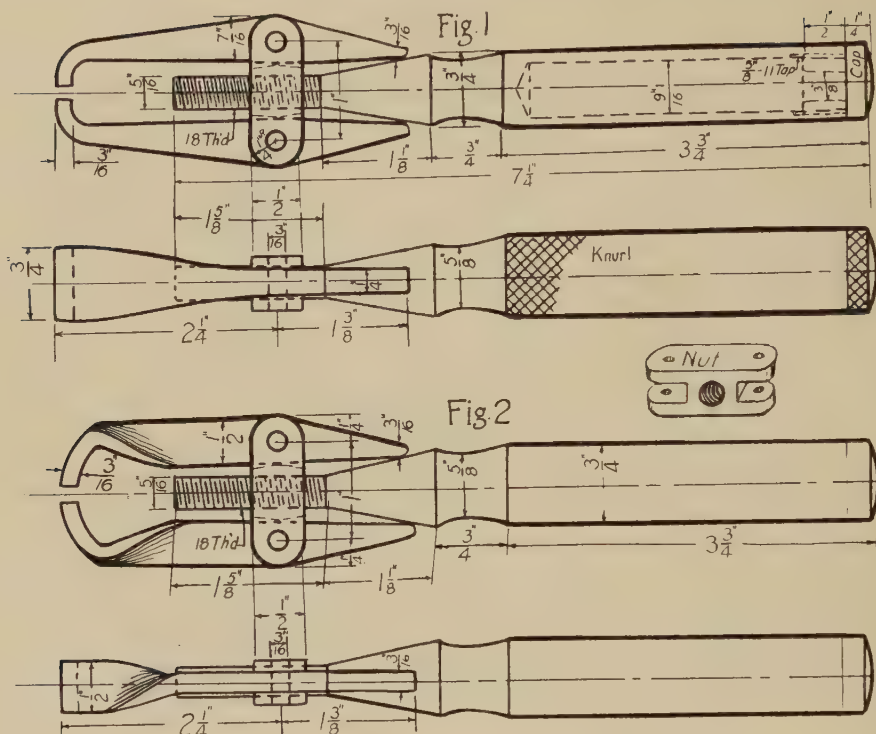
30. Inspect all parts critically. Put on the finishing touches, and assemble.

QUESTIONS

1. How may a cylinder be made to run true in an independent chuck?
2. How may finished work be gripped without being marred by the jaws?
3. Should the drill or the spindle turn, when boring an axial hole? Why?
4. What is the mechanism of a universal chuck?
5. How is a spiral chuck constructed? Is it universal or independent?

Problem 83
HAND VISES

Subject and Uses: A hand vise is a convenient tool for holding small articles, such as screws and pins, wire and drills. It also is very handy to use on small repair jobs, and in assembling instruments. It has a strong grip, yet is light in weight, and occupies but small space. The jaws may be closed by turning the handle forward, causing the cone-shaped portion of the handle to advance and spread apart the rear ends of the jaws. The handle, which is turned in a lathe, is finished all over. Its threaded end fits without play, into the nut. The jaws fit into openings, cut into the ends of the nut, and are held by pins on which they swing. The pins are riveted solid in the nut. It is essential that the three joints be made accurately, so that they may work freely and still have no perceptible play. The jaws in Figure 1 are forged from ¼ by ¾-in. stock, and are finished with a file. It is well to upset the end before the jaw is hammered broad, in order to have sufficient stock for ample thickness. The vise in Figure 2 is made by the same method as Figure 1, except that the jaws are cut, twisted, and bent cold, from 3/16 by ½-in. stock. (See drawing.)



DETAIL OF HAND VISES

Object of Lesson: Turning taper; knurling; threading; cutting openings in nut; forging jaws to shape; twisting and bending jaws to shape.

Tools and Equipment: Lathe; turning, knurling, and threading tools; drills; hack saw; forge; hammer, anvil and file; 5/16—18 thread die; taps.

Material Required: Machine steel: For handle, 13/16 in. round by 7⅛ in.; for nut, ½ in. square by 1½ in.; for jaws, 2 pcs. ¼ by ¾ by 2¾ in.; for pins, 3/16 by 1½-in. wire.

Procedure:

1. To make the nut, prepare the stock, and drill three transverse ¼-in. holes, one through the center and two parallel with it, ½ in. on center on either side.

2. Saw out and file to size, an opening at each end for the jaws.

3. Lay out and drill two 3/16-in. pin holes, as shown in the drawing, and countersink lightly.

4. Tap out the center hole for 5/16—18 thread, and file it to a smooth finish. Then drawfile and polish the entire nut.

5. Center the stock for the handle, and mount it on the lathe centers.

6. Turn the stock to ¾ in., and knurl the right end for 3½ in. Round-face the end to a smooth finish.

7. Use brass under the dog to shield the knurling. Reverse the work, and turn a concave in the handle. Turn the taper to 30 deg. Turn end to a 5/16—18 thread.

8. Finish the screw with a 5/16—18 thread die to make a close, running fit in the nut.

9. File and polish the handle to a fine finish.

10. Prepare the stock for the jaws. Heat the stock bright red, upset one end, and flatten it.

11. Heat the other end, and draw it out to a rectangular shape. (See drawing.)

12. Finish forging the jaws to a symmetrical form with the required section and curve.

13. Lay out and drill holes for the pins. File the jaws to the shape required.

14. Drawfile and polish the jaws. Caseharden the broad ends, the screw, and the nut thread.

15. Assemble the parts, insert the pins, and rivet. File and polish the ends of the pins smooth.

QUESTIONS

1. In upsetting a piece of steel at one end, should the rest be dipped in water before hammering is started? Why?
2. Why should all the necessary tools be ready for use before the steel is pulled from the fire?
3. Should hammering on metal stop as soon as the metal turns dark? Why?
4. What precautions must be taken to prevent burning the metal?
5. Could a space for small tools be drilled and fitted with a cap in this handle, as in Problem 82?

Problem 84
ECCENTRIC TURNING

Subject and Uses: A practical example of this problem can be found in the eccentrics which operate the valve mechanism on a reversible steam engine. Special attention should be given to the work of roughing and finishing the adjoining faces of the two eccentrics so that, when finished, they will lie in the same plane.

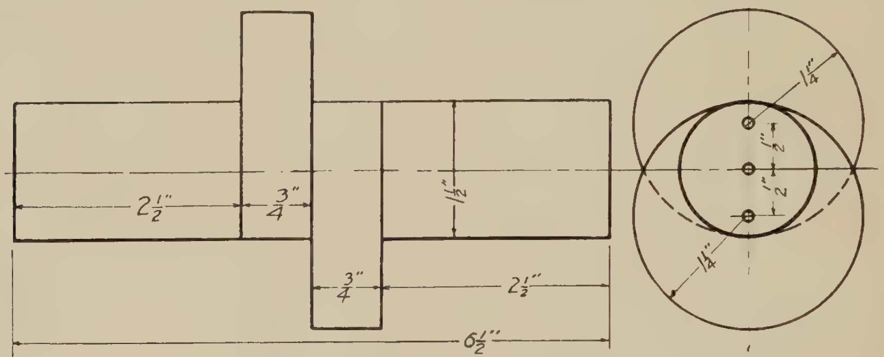
Object of Lesson: Learning how to lay out, turn, and face eccentrics to measure.

Tools and Equipment: Lathe and tools for turning; surface gauge; parallels; bench plate.

Materials Required: Iron casting of eccentric.

Procedure:

1. Get the casting required for this problem.
2. Chalk the ends, place the cylinder on two blocks, level the two eccentrics, and draw a line with a surface gauge through the center of each end.
3. Turn the work upside down, and draw another line across each end.



DETAIL OF ECCENTRIC TURNING

4. Rotate the work a quarter turn, and draw a line.
5. Turn the work upside down and draw a line.
6. Center-punch where the lines cross, and with this as a center, draw arcs across the first line with compass set to ½-in. radius.
7. Center-punch where the arcs cross, on the straight line, drill, and countersink.
8. Mount the work on the centers of the lathe. Rough-turn, leaving 1/32 in. for finish on the first cylinder.
9. Reverse the work, and turn the second cylinder.
10. Mount the work on the first side-center, and turn the first eccentric.
11. Change to the second side-center, and turn the second eccentric.
12. Mount on the middle-center, and rough-face the outer side of the eccentric.
13. Reverse the work and repeat for the second eccentric.
14. Mount the work on the first side-center, and rough-face the inner side of the second eccentric.
15. On the second side-center, rough-face the inner side of the first eccentric.
16. Rough-face the ends of the cylinder.
17. Following the preceding order of mounting, finish the ten surfaces, exactly to dimensions.
18. Test all measurements, and polish all over with oil and emery cloth.

QUESTIONS

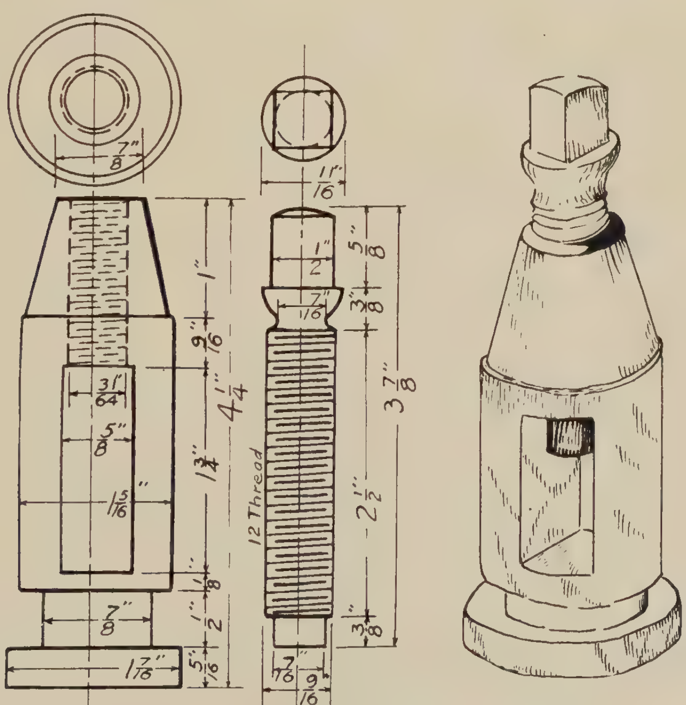
1. Why is it essential that the three centers on each end should be on a straight line? Why correctly spaced?
2. Why should the centers on both ends of the spindle lie in the same plane?
3. What is the shape of the tool with which the cylinder is finish-turned?
4. What tool is used for finish-facing the sides of the eccentrics?
5. How does oil on cast iron affect finish-cutting or filing?

Problem 85
TOOL POST

Subject and Uses: The tool post is a device which is mounted on the lathe carriage for holding metal-cutting tools. It is subjected to hard usage and enormous stresses, and, therefore, must be built on lines of great strength.

Object of Lesson: Working in tool steel; cutting and shaping tool opening; cutting necking; cutting and fitting threads; turning taper; tapping.

Tools and Equipment: Lathe and cutting tools; drill press and drills; cold chisel and files.



DETAIL OF TOOL POST

Materials Required: Round tool steel, for post, 1½ in. by 4⅜ in.; for screw, ¾ in. by 4 in.

Procedure:

1. Test the steel for hardness. If found necessary, anneal the steel by heating it slowly in a clean fire and bury it in hot ashes overnight.
2. Center both pieces, and mount the stock for the post on the lathe centers.
3. At slow speed, take a roughing cut to dimension, allowing for the finishing cut.
4. To cut the square groove at the bottom, make two cuts with the parting tool at the sides; turn, and face it to a smooth finish.
5. Lay out the rectangular tool opening. Drill three 9/16-in. holes within the limits, holding the work in a V slot or in a drill-press vise.
6. With a cold chisel, cut out the intermediate stock, and file the opening to exact size and shape.
7. Take a finish cut all over, and face the ends to measurement. File smooth and polish.
8. Into the small end of the post, drill a ¼-in. hole, and follow with a 31/64-in. drill.
9. Tap the hole 9/16—12 thread. Keep the tap well oiled while cutting the thread.
10. Mount the stock for the screw on the lathe centers, and take a roughing cut.
11. Turn the end to 11/16-in. finish, and cut a fine ring to mark the meeting line of the shoulder and the flats.
12. Grip the work in a vise, and file the flats square and to exact dimensions.
13. Mount the work on centers, and turn to a rounded form, the shoulder, the necking, and the top end.
14. Turn down the small end; face the end, and finish-turn the screw shank.
15. Cut a close-fitting, smooth 9/16—12 V thread in the post.
16. Harden the screw, and the thread in the post, by heating slowly to a cherry red, and quenching in oil. Burn off the oil, and quench again in oil. Repeat this process until the desired temper is attained for hardness, toughness, and strength.

QUESTIONS

1. Why should the lathe be run at a low speed in turning tool steel?
2. May steel, having chilled spots, be turned by reducing the speed?
3. Are high-speed steel lathe tools preferable to those of carbon steel?
4. What other form of tool post can you describe?
5. What form of tool holder is on the planer? on the wood-turning lathe?

Problem 86
GANG ARBOR

Subject and Uses: The advantage in using a gang arbor becomes evident as soon as a metal part is to be made in quantities. This arbor saves a great deal of time on the lathe and the milling machine, by making it possible to hold several pieces of the same kind at one time, to put them through one operation. The gang arbor should have a number of collars of different lengths so that pieces of any length may be held. The arbor shown here is typical. Other sizes, when needed, may be made, but the same relation between the several dimensions should be preserved, unless special requirements call for a deviation.

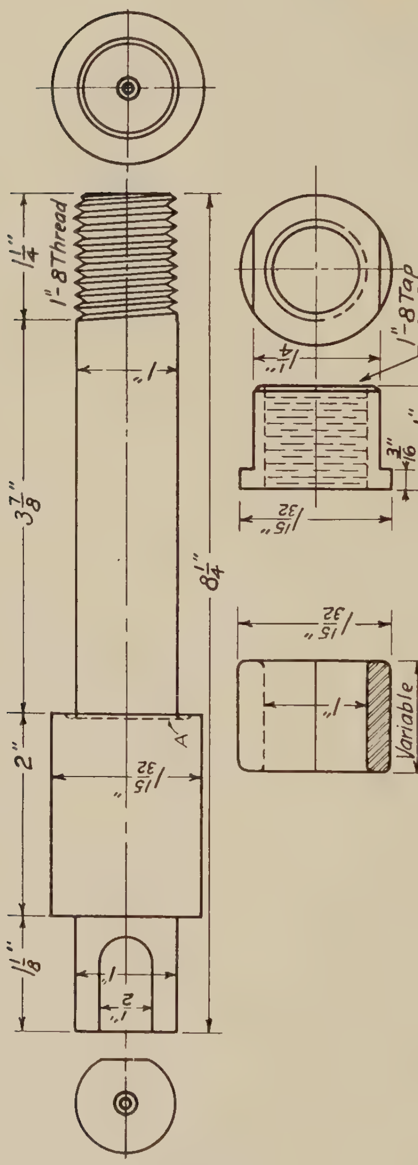
Object of Lesson: Turning and undercutting; thread cutting; making nut with flats; making collars; hardening centers.

Tools and Equipment: Lathe; turning, boring, and threading tools; drills; tap; file.

Materials Required: Round machine steel, 1½ by 11 in., for arbor, nut, and collar.

Procedure:

1. Cut off stock for the nut and the arbor to the lengths required.
2. Grip the stock for the nut in the lathe chuck, and face the ends to length.
3. Cut a circle around the stock showing the length of the flats.
4. Chamfer the edge, drill a ⅞-in. hole, and tap with a 1—8 thread tap.
5. Grip the nut in copper jaws, lay out and file the flats.
6. Make the collars. Grip the stock in the lathe chuck, and drill a 63/64-in. hole.
7. Ream the stock to 1 in., and round off the edges. (See section drawing.)
8. Center the stock for the arbor and mount it on the lathe centers.
9. Rough-turn to 1 1/32 in. up to the shoulder, from both ends.
10. Rough-face the shoulders and the ends of the arbor.
11. Finish the ends, round off the edges, and polish the centers round and smooth.
12. To caseharden the centers, heat them to a cherry red, rub with powdered potassium ferrocyanide, after which they must be reheated and quenched in water.
13. Clean the centers, turn the ends to size, file, and polish.
14. Cut the thread to fit the nut, 1—8 thread.
15. File flat for the clamping screw of the lathe dog.
16. Undercut the shoulder, as shown at dotted line A.



DETAIL OF GANG ARBOR

17. Screw the nut in place, turn to 1 15/32 in., file, and finish.

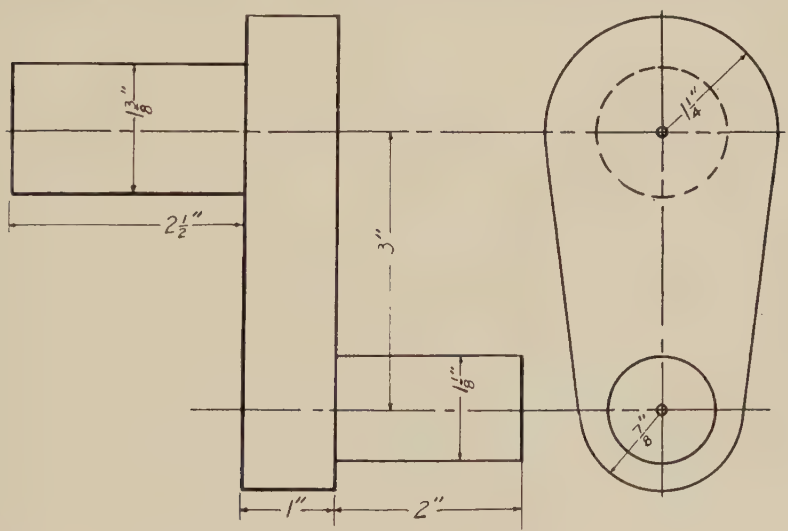
18. Turn the shoulder to 1 15/32 in., file and polish all parts to a finish.

QUESTIONS

1. In casehardening the centers, why is it necessary to handle only one center at a time?
2. How may the first center be kept cold while the second is being heated?
3. Why is the steel hardened only in the places where it is carbonized?
4. To what lengths should the spacing collars be made to form a set that would hold work of any length, within the capacity of the arbor?

Problem 87
CRANK TURNING

Subject and Uses: A crank is here represented by an elongated metal block with short shafts on opposite sides of each end, for the purpose of learning the problem involved in turning this kind of work. These



DETAIL OF CRANK TURNING

two shafts must be laid out and centered so that they may be turned and finished parallel. Therefore, it is necessary to locate the centers of the two shafts, and to place them on blocks on a surface plate in such a manner that lines may be drawn across the centers of both cylinders without moving them. The surface gauge is adjusted to the required height for drawing the lines. The work is then turned upside down and the lines are drawn. Next, the work must be rotated around one of the shafts a quarter turn, and lines drawn across the centers of the lower

shaft. Then the gauge point is raised 3 in., and lines are drawn across the centers of the upper shaft.

If the live center of the lathe is found too short for turning this crank, the dimensions for this problem may be reduced to suit the size of the lathe.

Object of Lesson: Learning how to locate centers and turn cylinders exactly parallel.

Tools and Equipment: Surface plate; surface gauge; lathe; turning and facing tools; file.

Materials Required: Rough cast-iron crank, in the general shape of the drawing.

Procedure:

1. Get the proper casting from the foundry.
2. Chalk the ends of the shafts, and block them up so that the axes are parallel with the surface plate.
3. Set the surface gauge level with the axes, and draw lines across the four centers.
4. Turn the shafts upside down and place them on the blocks as before, and draw lines.
5. Rotate the axis of one shaft 90 deg., and support it in position.
6. Draw lines across the centers of the lower shaft.
7. Raise the gauge point exactly three inches, and draw lines across the centers of the upper shaft.
8. Center-punch the centers, drill, and countersink 3/16 in. deep.
9. Mount the shafts on lathe centers, and rough-turn them, leaving 1/32 in. for finish.
10. Rough-face both sides of the block, starting the cut at the shaft, and feeding outward with power feed. Leave 1/64 in. for finish.
11. Rough-face the ends of the shafts, leaving 1/64 in. for finish.
12. Take a smooth-finish cut on the shafts, on the crank sides and on the shaft ends.

QUESTIONS

1. Why should the crank pin in a steam engine be parallel with the shaft?
2. Are most steam engines equipped with cranks similar to the layout of this problem?
3. Where are the crank pins located in a locomotive?
4. Where are the crank pins located in a gas engine?
5. What makes a locomotive go forward when the pressure on the crank pin is backward?
6. In turning cast iron, how do the chips differ from those of steel?
7. In rough-facing the side of the crank, did the tool chatter? Why?
8. In cutting through scale, does the cutting edge stand up better at low cutting speed than at high? Why?

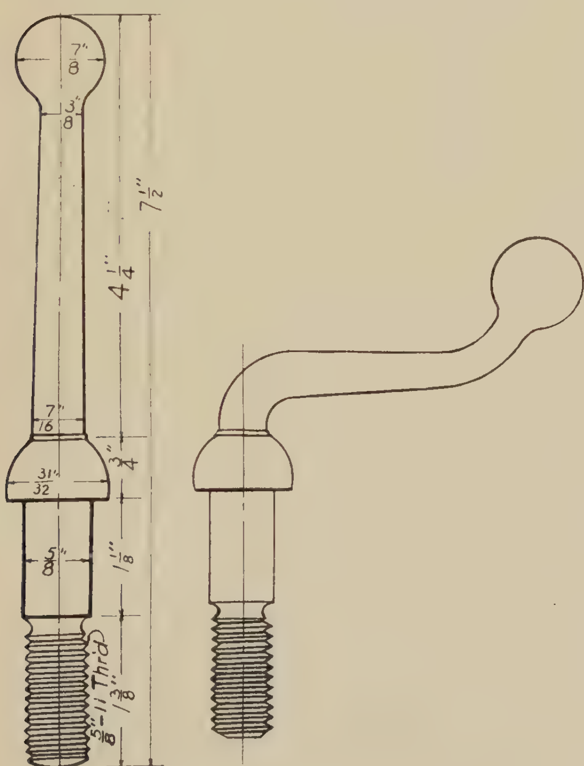
Problem 88
TAILSTOCK CLAMP SCREW

Subject and Uses: The tailstock clamp screw described herewith is made of tool steel. It is first finished to dimensions in the lathe. It is then heated to a dull red and the threaded end is gripped in copper jaws. A piece of tubing is next slipped over the ball and down over the taper for a short distance, and the handle is bent in a simple curve. The reverse curve is formed by gripping the taper handle at a point one fourth its length from the ball, and bending it back by striking it carefully with a piece of babbitt. See that the handle is bent at the right points to the proper curves, and that the surface is not marred.

Object of Lesson: Forming ball and oval shoulder; turning taper; threading; bending graceful reverse curves.

Tools and Equipment: Lathe; turning and threading tools; heating and bending appliances.

Materials Required: Round tool steel, 1 by 7⅝ in.



DETAIL OF TAILSTOCK CLAMP SCREW

Procedure:

1. Select and cut off the stock. Center and mount it on the lathe centers.
2. Rough-turn the stock full length, to ⅞-in. diameter, except at the location of the 31/32-in. shoulder. Mark the shoulder by parting cuts.
3. Turn the threaded end to within 1/64 in. of the finish size.
4. Face the square shoulder, and face and chamfer the end.
5. Reverse the work, and cut away the stock between the ball and the oval shoulder.
6. Set over the tailstock center, and turn the handle taper.

7. Make templates for the ball and the oval shoulder, by cutting and filing pieces of tin to exact shapes.

8. Turn the ball to fit the template, by manipulating both lathe feed handles simultaneously, using a sharp, round-nose tool.

9. Turn the convex shoulder.

10. Finish-turn the taper, the ball, and the shoulder; file, and polish.

11. Reverse the work. Align the lathe centers. Finish-turn the shank for threads, and cut the necking.

12. Gear up the lathe, and cut the threads to fit the screw gauge.

13. Heat the handle and bend it to the required reverse curve.

14. Harden the handle by heating and quenching in oil.

QUESTIONS

1. Why is a tailstock spindle clamped?
2. Describe the mechanism used for clamping the spindle, where two cylindrical sections are drawn together to press on the side of the spindle.
3. Describe other methods used for clamping tailstock spindles.
4. In turning on centers, is it necessary to avoid backlash on the spindle screw, when the spindle is clamped? Why?

Problem 89
DRILL CHUCK

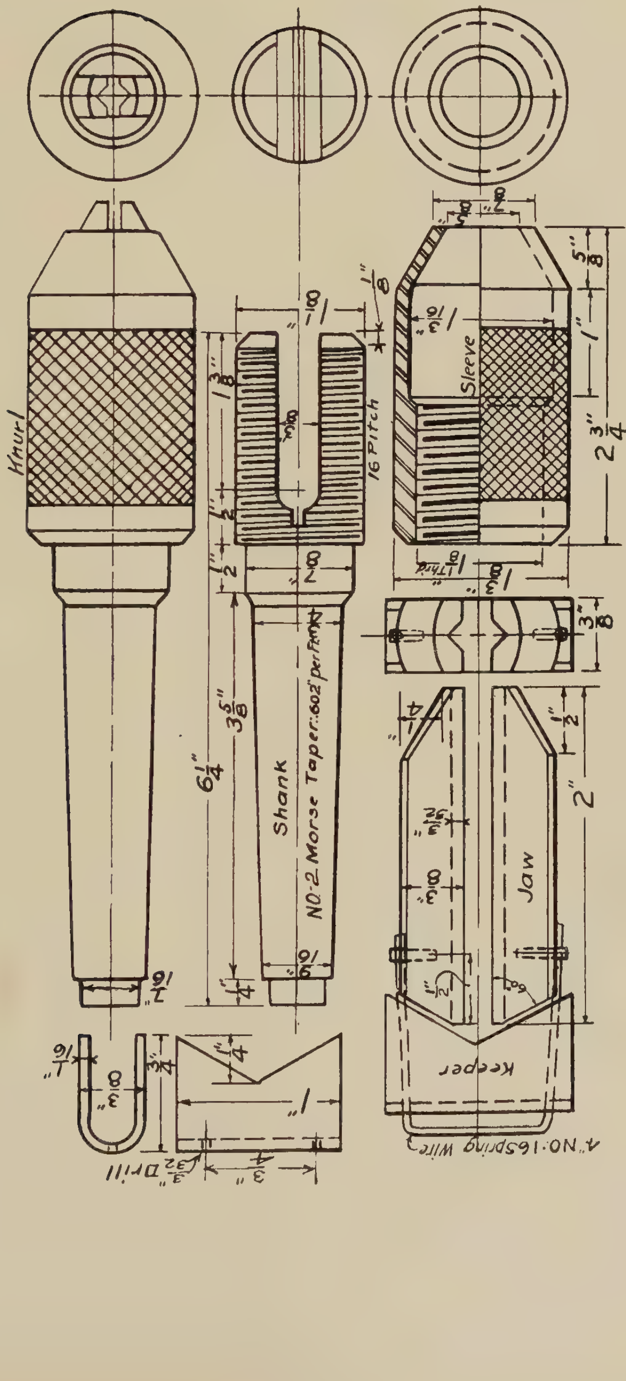
Subject and Uses: This tool is so designed that with ordinary shop equipment, the student with mechanical experience may be able to make it.

The small end of the shank has a Morse taper, while the large end is straight and threaded to fit the sleeve. In this large end a slot is cut through the center, forming two prongs, which in turn serve to house and drive the chuck jaws. The front outer faces of the jaws are tapered and may be compressed by the sleeve, the inside of which has a corresponding taper at the front end. The rear ends of the jaws are slant, and fit against the slant side of the keeper. They are held together by the U spring which, passing through holes in the keeper, is pinned to the jaws and serves to spread them. Along the inner faces of the jaws are cut rectangular V grooves, to grip the drills so that they are in line and run true.

Object of Lesson: Inside boring; taper reaming; thread cutting; making jaws and housing.

Tools and Equipment: Lathe and chuck; taper reamer; inside thread and boring tools; drills; knurling and thread tools; hack saw; file.

Materials Required: Machine steel: For shank, 1¼ in. round by 6⅜ in.; for sleeve, 1½ in. by 2⅞ in.; for jaws, ⅜ in. square by 4⅛ in.; for keeper, 1/16 by 1 by 1¾ in.; for spring, No. 16 spring wire 4 in. long; for spring pins, a 10d nail.



DETAIL OF DRILL CHUCK

Procedure:

1. To start the sleeve, grip the stock in the lathe chuck; face and drill a ⅝-in. hole clear through. Follow with a ⅞-in. drill, 2¼ in. deep, and a 1-in. drill, 2⅛ in. deep.

2. With a lathe tool, bore out the taper at the inner end of the hole, and finish it with a flat taper reamer. (See the drawing.)

3. Bore out the 1 3/16-in. recess, 1 in. long, and cut the inside thread 1⅛ in. 16 thread or 1/16 pitch. Remove the sleeve to be finished later on the shank.

4. To make the shank, center the stock, mount it on centers, and rough-turn it all over to dimensions.

5. Finish the small end to a No. 2 Morse taper of .602 in. per foot.

6. Finish the large end to 1⅛ in. Turn the shoulders to measure, and finish.

7. Cut the thread 1⅛ in. 16 thread or 1/16 pitch, to fit into the sleeve.

8. Mount the sleeve on the shank, turn it to dimensions, knurl, and polish to a perfect finish.

9. Locate and drill a 3/32-in. and a ⅜-in. hole, 1 11/16 in. and 1⅜ in. respectively from the large end of the shank. The holes are parallel and pass at right angles through the shank axis.

10. Drill a ⅜-in. hole axially into the large end of the shank, 1⅜ in. deep.

11. Make two parallel hack-saw cuts to remove the stock for the ⅜-in. opening in the threaded portion, starting at the large end of the shank, 3/16 in. each side of the center, making the cuts 1⅜ in. long. Also, make saw cuts down farther, into the 3/32-in. hole, to make place for the U spring. File the openings to a finish.

12. To make the keeper, bend the stock over ¼-in. round iron. Lay out the angle, saw out the stock, and drill two 3/32-in. holes, ¾ in. apart, for the U spring. File the keeper to a finish.

13. Make the jaws 2 in. long. File the front end sloping 30 deg. to fit the taper inside the sleeve, and the rear end 60 deg. with the axis to fit up against the keeper.

14. File 90-deg. grooves along the inner faces of the jaws, 3/32 in. deep.

15. Drill a ⅛-in. hole into the outer face of each jaw, ½ in. from the rear end, for the spring pin. File the pins to drive fit into these holes.

16. Bend the spring to shape and insert it through the holes in the keeper. Drill holes through the pins for the spring. File grooves along the outer face of the jaw for lodging the spring.

17. Caseharden the jaws. Insert the spring through the pins, and drive the pins into the jaws.

18. Assemble the parts by fitting them to conform to the sleeve cavity. Slide the spring, the keeper, and the jaws into the slot between the shank prongs, and fit them together carefully.

19. Screw the sleeve into position. See that all parts work perfectly, and finish.

QUESTIONS

1. Why are the rear ends of the jaws and the edges of the keeper made to slope?
2. As the sleeve compresses the jaws, do they exert an end thrust against the keeper? Why?
3. Why should the spring be allowed some end play on the keeper?

Problem 90

LARGE TAP WRENCH

Subject and Uses: The dimensions assigned to the different parts of this tool are so ample, that it will be found to stand up well under hard usage. Yet, the tool is handy and light, easily adjusted, and of a capacity to hold taps as large as those used in ordinary work. Moreover, the operations involved in making this wrench are so simple that they can be handled easily on the average shop equipment. The wrench is composed of a handle, a plunger with spring, and a sleeve.

Object of Lesson: Spindle turning; drilling on steady rest; threading; fitting; knurling.

Tools and Equipment: Lathe; chuck; threading, knurling, and turning tools; taps; drills; hack saw; file.

Materials Required: Round machine steel: for handle, 1 by 8¼ in.; for sleeve, ¾ by 3¼ in.; for plunger, ½ by 4½ in.; for spring, No. 20 spring wire 8 in. long; 3/32-in. pin, ¼ in. long.

Procedure:

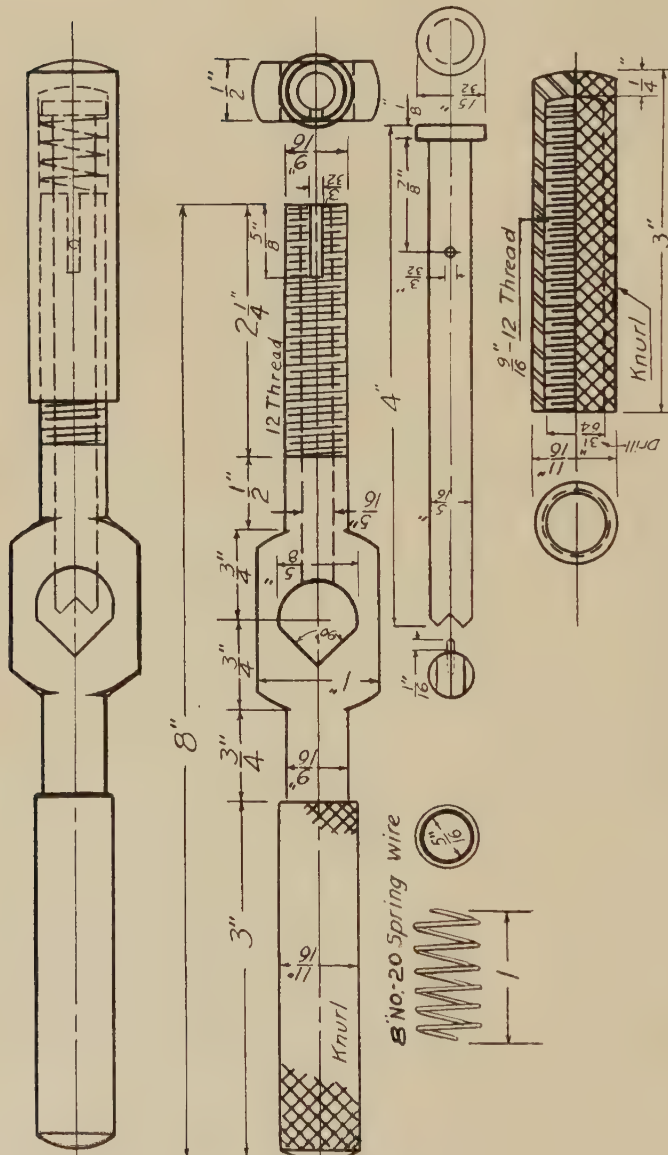
1. To make the sleeve, grip the stock in the lathe chuck, drill a ¼-in. hole, 2¾ in. deep, and follow with a 31/64-in. drill, 2¾ in. deep.

2. Lock the lathe with the back gears. Tap out the hole 9/16-in. 12 thread by hand; steady the tap on the tail center. Use oil on the tap.

3. Face the end. Reverse the work in the chuck, and center the other end. Remove the work, and finish later.

4. Center the stock for the handle, mount it on centers, and rough-turn it to within 1/64 in. of the finish size.

5. Chalk the large center portion. With a surface gauge, draw two lines lengthwise, ½ in. apart; also one diametrically opposite each of these.



DETAIL OF LARGE TAP WRENCH

6. Saw off stock to form flat, parallel faces, and file to lines. Polish faces smooth.

7. Locate, mark, and drill a hole in the center of the face, as shown in the drawing.

8. File the side of the hole opposite the plunger to a 90-deg. angle.

9. Tie the dog, which is fastened on the large end of the handle, to the lathe faceplate with a cord, and adjust the steady rest to the small end. Oil this bearing.

10. Drill a 5/16-in. axial hole, true, into the handle for the plunger, 3¼ in. deep.

11. Re-center the end, and remove the steady rest. Turn all over to a finish, on the lathe centers.

12. Cut a 9/16-in. 12 thread to a firm, running fit inside of the sleeve. Face the end to length.

13. Screw the sleeve on the handle, and mount it on centers. Turn the sleeve to size, and knurl.

14. Round-finish the end. Reverse the work, and put sheet copper around the sleeve, under the dog.

15. Knurl the other end of the handle, and round-finish the end. File and finish all over.

16. Center the plunger, turn a 15/32-in. shoulder and face it to length. Turn the plunger to 5/16 in.

17. Locate, mark, and drill a hole for the pin. Fit the plunger into the handle.

18. With double blades, saw a slit 3/32 in. wide, into the threaded end of the handle, ⅝ in. deep.

19. Press the pin into the plunger, and fit it to slide in the handle slit.

20. File a 90-deg. V notch in the end of the plunger, to dimensions.

21. Wind an open spring on ¼-in. wire, and cut the spring to length.

22. Place the spring in place. Fit and polish the parts, and assemble.

QUESTIONS

1. With a spindle held in a revolving lathe chuck, how may the drill be started true in the spindle end?
2. In turning the slender spindle, how is it kept from springing at the center?
3. In knurling, how may the tool marks be made continuous?
4. Why is a spring wound around a spindle of smaller diameter than the diameter required for the spring?
5. How are the turns of a compression spring spaced? How may it be done?

Problem 91

BACK COUNTERBORE

Subject and Uses: The back counterbore is a handy tool for facing up work, square with the hole in which the bar rotates. The cutter is readily slipped into place and fastened, after the bar is inserted through the work. This tool is composed of the following parts: The bar A, through which an axial hole is bored, houses plunger B, which in turn is forced down against the cutter C holding it in a central position, when the wedge-shaped key D is driven into the slot through the bar. When it is desired to remove the cutter C, the key D is driven back into the bar, so that the small end is flush with the surface of the bar, and the spring E pushes the plunger B up into the notch in the key D, and releases the cutter C. In this manner, the key D is always kept in place, and is prevented from getting lost.

Figure 1 shows the key driven into the bar, depressing the plunger, compressing the spring, and holding the cutter. Figure 2 shows the key driven back, releasing the cutter.

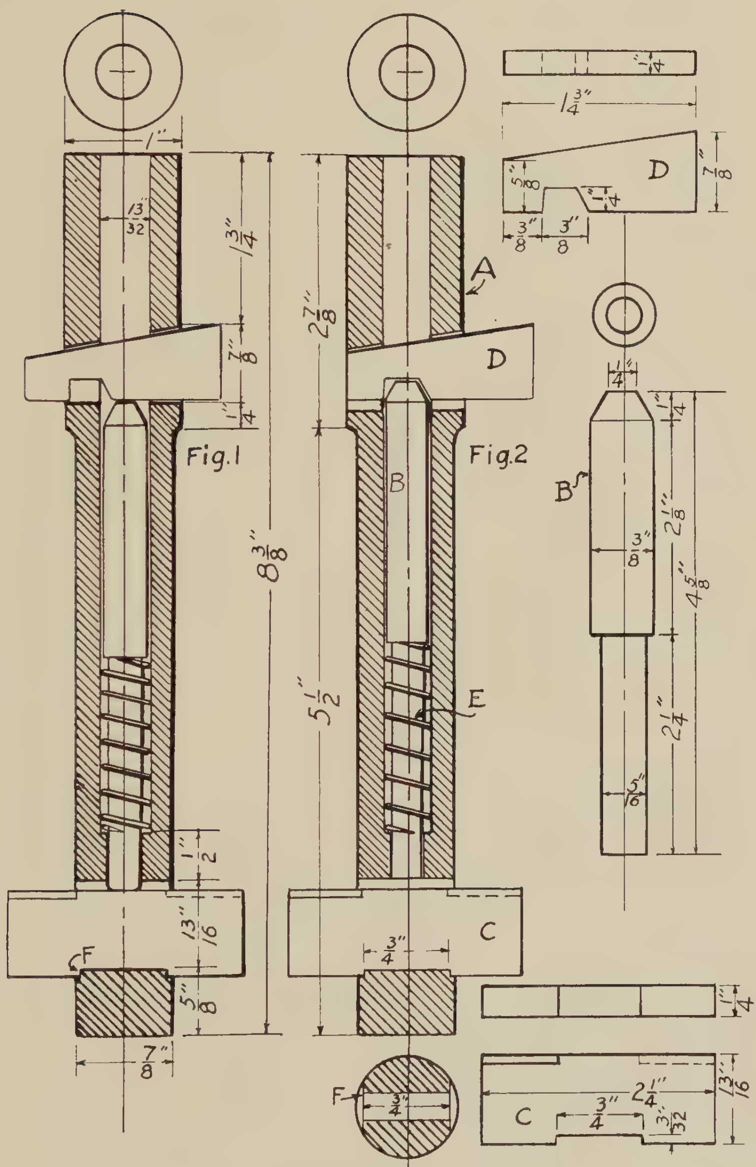
Object of Lesson: Drilling a long hole; cutting and fitting slots through the bar for the cutter and the key; shaping the key and the cutter; hardening and tempering the cutter.

Tools and Equipment: Lathe; drill press; drills; cape chisel; vise; hammer; files.

Materials Required: For the bar, round machine steel, 1⅛ by 8½ in. Tool steel for the following: the plunger, ½ in. round by 4¾ in.; the cutter, ¼ by 1 by 2½ in.; the key, ¼ by 1 by 2 in.; the spring, No. 20 wire, 10 in. long.

Procedure:

1. To make bar A, grip the stock in a lathe chuck and face the ends.
2. Drill an axial hole, 5/16 in. diameter, 7 in. deep.
3. Countersink the 5/16-in. hole. Reverse the work, and center the other end.
4. Mount the bar on the lathe center and turn and finish it to dimensions.
5. Drill an axial hole into the bar 13/32 in. diameter, 6½ in. deep. (See drawing.)
6. To cut the slots for the cutter and the key, apply a surface coating of chalk, and with a surface gauge draw diametrically opposite lines along the surface.
7. Lay out and drill 7/32-in. holes on both lines for the key and the cutter slots.
8. With a cape chisel, cut out the stock left between the holes. File



DETAIL OF BACK COUNTERBORE

the sides of the slots parallel and flat, and the ends square to fit the key and the cutter, both of 1/4-in. uniform thickness. The upper side of the key slot is tapered to fit the tapering width of the key. The lower side of the cutter slot is filed so that the shoulders F will fit the recess in the cutter C.

9. To make the plunger, center the stock, and mount it on the lathe centers.

10. Face the ends to length, and turn the plunger to dimensions. Taper the top end, file to a finish, and polish.

11. Wind the open spring on a 1/4-in. rod to fit on the plunger, as shown at E.

12. Make the key as shown at D, either in the shaper or with a hack saw and a file, so that the notch will fit over the top end of the plunger.

13. Make cutter C to dimensions, so that the recess fits the shoulder, and the cutting edge has the proper clearance and is square with the bar.

14. Heat the cutter evenly and harden it in water. Draw the temper on a hot iron block.

15. Assemble the parts, adjust them to a perfect fit, and test the tool on a piece of work.

QUESTIONS

1. When facing the surface around a hole, should the bar always fit the hole?
2. Under what conditions is a counterbore indispensable for facing a surface?
3. In hardening a cutter, what causes cracks to develop?
4. What precautions should be taken to prevent the cutter from cracking?

Problem 92

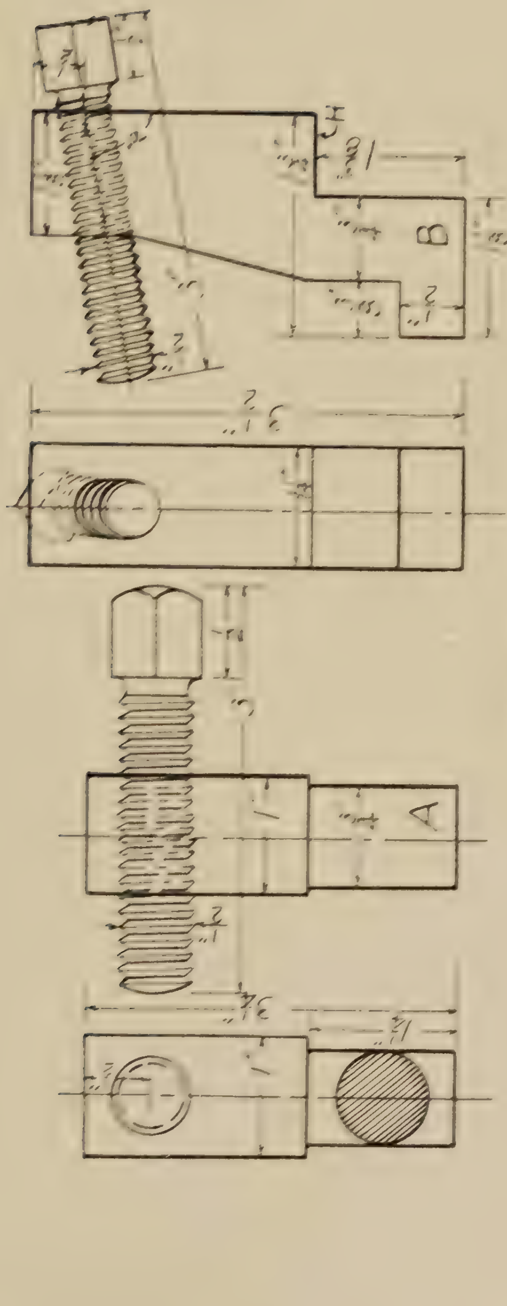
PLANER STOPS

Subject and Uses: Two distinct types of planer stops, A and B, are shown in the drawing. One, A, the lower part of which is turned cylindrical, fits into the holes in the planer table, and may be used as a stop to keep work from sliding lengthwise on the table, as well as for lining up work and holding it from moving sidewise. The other, B, which is rectangular in section and is a milling machine or shaper job, fits into the T slots in the planer or milling-machine table, where it is used to brace work against the table. The downward slope of the screw is a feature that may be applied on either type of planer stop. Through the heel H, this stop has a solid bearing on the top of the table, exerts no undue stress on the T slot, and is strong and effective as a clamping device.

Object of Lesson: Shaping; turning; drilling; tapping; thread cutting.

Tools and Equipment: Shaper; lathe; turning and threading tools; drills; taps.

Materials Required: Machine steel: for stop A, 1 in. square by 3 1/4



DETAIL OF PLANER STOPS

in.; for stop B, 1¼ by 1¾ by 3½ in.; for screws for A and B, two pieces, ½ in. square by 3 in.

Procedure:

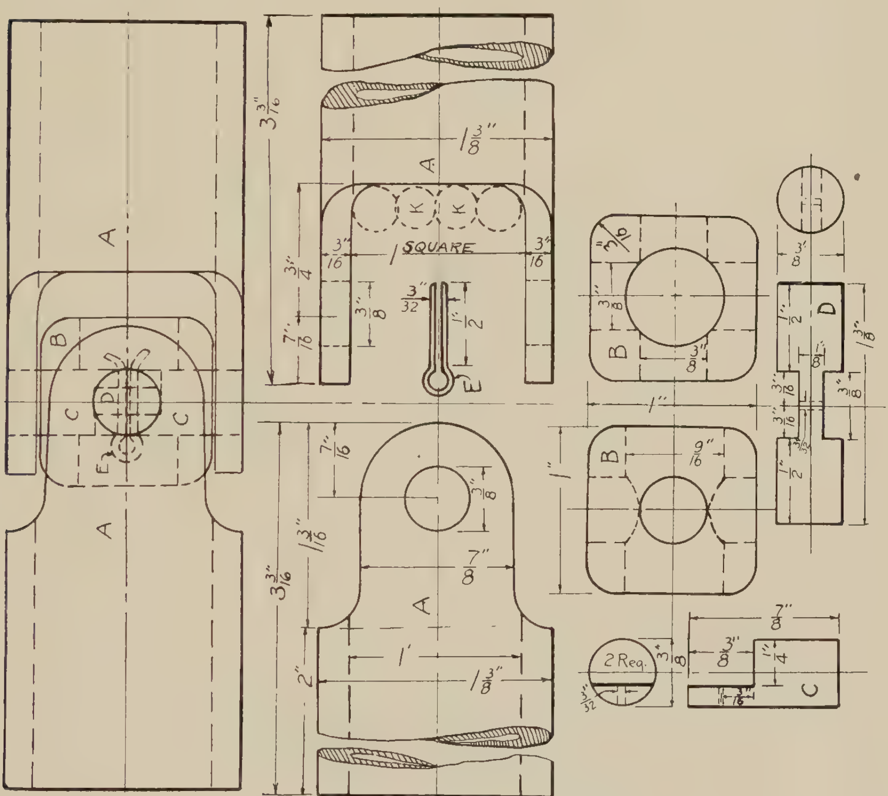
1. To make stop A, cut off the stock to length, draw intersecting diagonals across each end, and center.
2. Mount the stock on the lathe centers, and face the ends.
3. Set the parting tool, locate and cut down the stock for the shoulder to the required depth.
4. Turn the shank to a running fit in the hole in the planer table.
5. Locate and drill a 13/32-in. hole. Tap the hole ½—13 thread.
6. File the shank smooth, and finish by removing the sharp edges and the corners.
7. To make stop B, cut it to length from bar stock, or forge it to a rough shape.
8. Grip the stock in the shaper vise, and shape out the rectangular recess H to dimensions.
9. Turn the work upside down in the vise, and plane it to dimensions. On the chalked side-surface of the work, it is well to lay out the exact shape of the different parts, and center-punch them on the finish lines.
10. Locate and drill a 13/32-in. hole for the screw. Tap the hole with ½—13 thread.
11. File the stock smooth, and finish it by rounding off the sharp edges and the corners.
12. To make the screws, cut off the stock to length, center, and mount it on lathe centers.
13. Turn the shank to dimensions. Face the ends and chamfer. Cut a rounded necking.
14. Gear up the lathe, set the threading tool, and cut a ½—13 thread to a firm fit in the stops.
15. Insert a screw into both stops, A and B. Limber them up until they can be turned with the fingers. File the ends of the screws to a finish and caseharden them all over.

QUESTIONS

1. How does the cutting action of the shaper differ from that of the lathe?
2. Why is a shaper preferable to a planer for small work?
3. Could stop B be shaped with a hack saw and a file? If so, how?
4. Should the planer stops be machined where no fit is required? Why?
5. Could stop B be machined more profitably on the milling machine than on the shaper? Why?

Problem 93
UNIVERSAL JOINT

Subject and Uses: A universal joint is used for coupling together two shafts which turn at an angle to each other. Where one of the shafts must turn at various angles such as the feed shaft of a milling machine, or where rotary motion in out-of-the-way corners is in demand, this form of joint finds practical application.



DETAIL OF UNIVERSAL JOINT

The joint shown in the drawing is strong, simple, and easily made. It has no threaded parts to work loose and no pressed fits to make it hard to disassemble. The joint is composed of the two semicircular end jaws AA, which have ⅜-in. axis pinholes, and are alike in all respects. The center block B, located between the four jaws, is a 1-in. cube with ⅜-in. holes intersecting at right angles for the axis pins, and a 9/16-in. hole

through the block at right angles to the holes for the axis pins. The axis pins are in three parts D, C, and C, and are held together and locked in place by cotter pin E. These axis pins push-fit into the ⅜-in. holes of the center block and the jaws. The pin D is full length through the joint, and a space is milled off on both sides, at the middle, leaving a center bar ⅛ in. thick by ⅜ in. long. The other pin is composed of two parts CC. Each of these parts has one end partly cut away leaving a projecting ear ⅛ in. thick and ⅜ in. long. Coming from opposite sides, the ears or pins CC lap over the flattened middle of pin D, on both sides. The cotter pin E, inserted through a hole which is drilled through the three thicknesses, locks the axis pins in position.

The jaw ends may be cut directly on the ends of the shafts that they are to connect, or they may be made in the form of sleeves shown in the drawing by dotted lines, and then pinned to the shafts.

Object of Lesson: To cut out semicircular jaws and an intermediate opening; to shape a perfect cube with exactly spaced holes drilled at right angles; to shape overlapping pins to exact dimensions.

Tools and Equipment: Lathe and tools; drill press and drills; hammer; hack saw; chisel and files.

Materials Required: For the jaws: machine steel or heavy tubing 1½ in. diameter, 6¾ in. long; for the center block, 1⅛-in. cube of tool steel; for the axis pins, 4 in. of ⅜-in. drill rod; for cotter pin, 2 in. of No. 16 steel wire, or use a standard cotter pin.

Procedure:

1. To make jaw A, center the stock, mount it in the lathe, turn it to 1⅜ in., and finish.
2. Lay out and drill the holes shown at A in the drawing, that is, the axial hole and the K holes. Cut the stock in two.
3. With a hack saw, make cuts along the side lines of the jaws.
4. With a hack saw and a chisel, cut away the side stock, heat and flatten the jaws, and file or plane them to the correct shape and size.
5. With a surface gauge and dividers, lay out the holes for the axis pins and the shape of the jaws.
6. Drill and ream the holes to ⅜ in. Saw and file to form the curving contour of the jaws, and finish them.
7. To make the center block B, plane a cube exactly 1 in. square.
8. Locate and center-punch the true center of each face. Use a surface gauge.
9. Drill a 9/16-in. hole in the center of two opposite faces, and in the centers of the other four faces, drill and ream ⅜-in. holes. Perfect workmanship is essential for practical and good results.

10. Round off all edges to a 3/16-in. radius. Fit the jaws of A over the cube.

11. To make pin D, mill out two parallel slots midway of the length, ⅛ in. deep and ⅜ in. long, leaving the connecting bar ⅛ in. thick.

12. To make pin C, cut away the stock at one end ¼ in. deep by ⅜ in. Use a hack saw and a file. The thickness of the ear should caliper ⅛ in.

13. To fit the pins in position, insert pin D through the hole in block B, and fit the pins C into the other ⅜-in. holes, so that the ears overlap both flats of pin D.

14. When all are in position, drill a hole through the three thicknesses for a cotter pin; then disassemble.

15. Inspect the parts. Polish all parts and reassemble. Place block B between the jaws of A, insert pin D, put the other jaws over block B, and push pins CC into position to overlap the flats on pin D, so that the cotter-pin hole comes in line. Insert the cotter pin to lock the parts together.

16. File the ends of the pins and finish them perfectly.

QUESTIONS

1. Describe a universal joint with parts different than those given here.
2. Describe the construction of flexible shafting. Where is it used?
3. As applied to machinery, how is the ball-and-socket joint constructed?
4. In that sense, how is the knuckle joint used?
5. Assuming that other sizes of the joint here described, are practical, if the same relative dimensions are preserved, what would be the diameters of the jaws and axis pins for a joint having a ¾-in. cube for a center block?

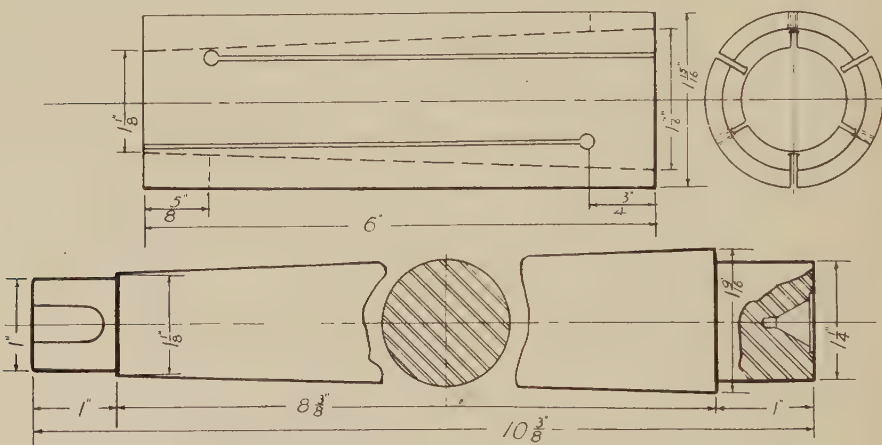
Problem 94
EXPANSION ARBOR

Subject and Uses: This arbor can be varied in size, so that it will fit holes of different diameters. It consists of two parts, the arbor and the sleeve. The arbor is turned to standard taper, and when it is pressed into a sleeve that has a corresponding inside taper, it expands the sleeve to fit the work that is to be turned on the arbor. The outside of the sleeve is straight, not tapered. Six slots are cut through the sleeve wall extending within ⅝ in. and ¾ in. of its full length, starting alternately at opposite ends. (See drawing.) Holes are located and drilled at the ends of the slots, and add much to the flexibility of the sleeve. The slots can be cut on a milling machine, or they can be sawed with a hack saw, by inclining the saw toward the axis of the sleeve. The finishing cut can be made by removing the saw blade from the frame and gripping it with small clamps.

Object of Lesson: Counterboring; polishing, and hardening centers; turning, boring, and reaming long taper; cutting long slots.

Tools and Equipment: Lathe; chuck; turning and boring tools; taper reamer; drills; hack saw.

Materials Required: Round machine steel; for arbor, 1⅝ by 10½ in.; for sleeve, 2 by 6¼ in.



DETAIL OF EXPANSION ARBOR

Procedure:

1. Prepare the stock for the sleeve and mount it in the lathe chuck.
2. Drill a 1-in. hole through the stock.
3. Follow with drills of increasing sizes to decreasing depths, to taper the hole, leaving enough stock to bore the full taper wanted.
4. Adjust the compound rest to the required angle and bore out the hole to the correct taper.
5. Run the lathe at the slowest speed, and ream the hole. Use oil freely during the reaming. Arrange a tool in the tool post to act as a safety stop against the dog on the reamer to keep the reamer on the tail center. Use the carriage to pull out the reamer to clear it of chips. This should be done at frequent intervals during the operation.
6. Face the ends of the sleeve.
7. Center the stock for the arbor, drill and countersink it to ample size, and counterbore 1/16 in. deep.
8. Mount the arbor on the lathe centers, and face the ends.
9. Turn the end shanks for the lathe dog, round off the edges, and file the flats for the setscrew.
10. Grip the arbor in the lathe chuck, and polish the centers with oil and emery.

11. Caseharden the ends of the arbor, and polish the centers.

12. Mount the arbor on centers, and turn the taper to a perfect fit in the sleeve.

13. Finish the arbor with a dead-smooth file, and polish it bright.

14. Press the arbor into the sleeve, and turn the sleeve straight, smooth, and to size.

15. File and polish the sleeve to a fine finish.

16. Mark with a hair line around the sleeve, 3/4 in. from the thin end and 5/8 in. from the thick end. Also, draw a longitudinal line with a sharp-pointed tool, by moving the lathe carriage. Use this as a starting line.

17. Step off each circle with dividers, into six equal steps, and mark with a center punch. With a pointed lathe tool, mark the longitudinal lines along the sleeve surface end to end, through each pair of points as follows: Set the tool point on one of the marks at the left end. Move the lathe carriage by hand. Draw a line to the right end. Move the sleeve one-sixth turn. Set the tool on the next mark at the right, and draw it to the left end. Make three pairs of lines that way.

18. Remove the arbor from the sleeve, and drill three 3/16-in. holes at each end as shown in the drawing.

19. Saw slots in the sleeve, following each of the six lines from the end to the hole, alternating between the ends for each of the six succeeding cuts.

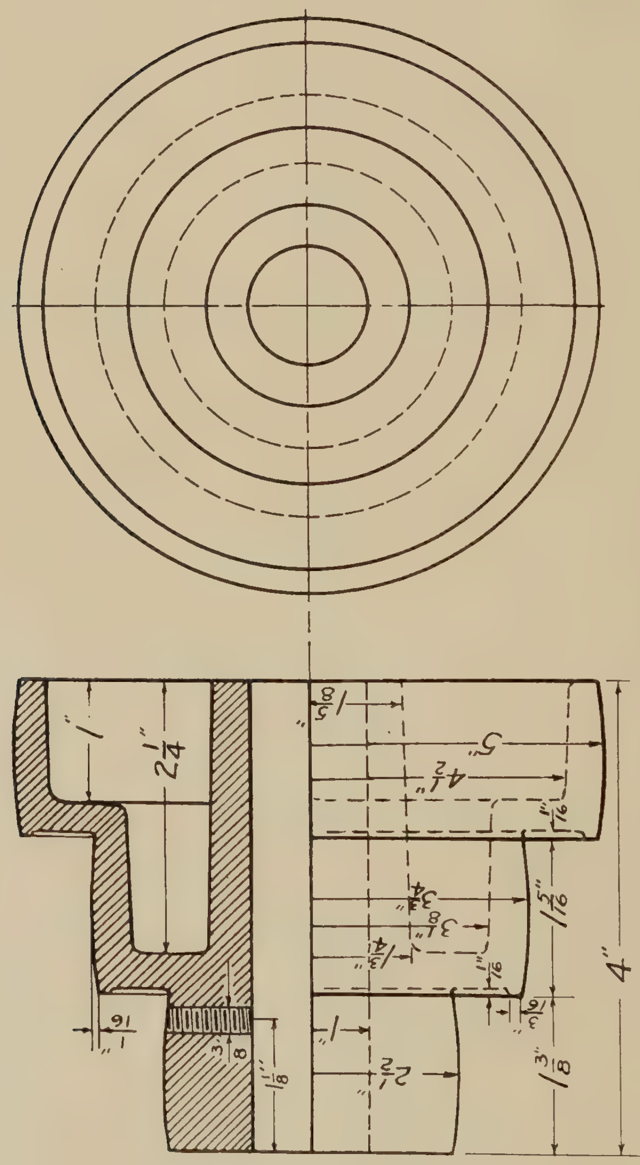
20. File off all burrs, and inspect the work for possible improvements.

QUESTIONS

1. In setting the lathe to the proper taper for the arbor, is the taper reamer an aid if it is equal to the arbor in length?
2. How is the taper per foot of the reamer determined?
3. How may the angle made by cutting edge and axis of the reamer be computed in degrees and minutes?
4. How is the arbor tested in the sleeve for correct taper?
5. May sleeves of different diameters be used on this arbor?
6. Should they be at the same rate of taper? of the same length? Why?

Problem 95
THREE-STEP CONE PULLEY

Subject and Uses: This pulley may be used to drive the spindle of a small speed lathe, or as a feed pulley on a drill press, a lathe, or a milling machine. It is an excellent shop project, as it furnishes practical means for acquiring experience in chucking, turning the taper hub on a mandrel, the internal pulley surface, and the crowns and shoulder recesses of the flat-belt pulleys. It is important that the measurements are taken exactly, that the tapers are figured out, and that the set-overs are made as required.



DETAIL OF THREE-STEP CONE PULLEY

Object of Lesson: Learning to true up a pulley in a chuck; boring out and reaming a hole; doing internal and external turning; turning a crown on a pulley.

Tools and Equipment: Lathe; chuck; drills; boring and turning tools; reamer; mandrel.

Materials Required: Iron pulley casting.

Procedure:

1. Turn up the pulley pattern as shown in the drawing, with ¾-in. core prints, allowing ⅛ in. finish all over. Have the casting made and pickled.
2. Grip the small end of the pulley in a lathe chuck, and adjust it so that the hub and the flange run true.
3. Start the drill true, drill out the hole, bore it to size, and ream and oil the hole.
4. Press the mandrel into the pulley and mount it on the centers of the lathe.
5. Take a straight cut over each pulley, leaving 1/32 in. for finish.
6. Rough-face the three shoulders and the large pulley edge.
7. Reverse the work. Rough-turn the inside of the flanges and the shoulders.
8. Set over the tail center, and turn the hub to the required size and taper.
9. Rough-face the inner end of the hub cavity.
10. Set the tail center over toward the back, start at the middle of the pulley, and turn the taper crowns, reversing the work for the tool setting of each pulley.
11. Finish taper turning the inside of the flanges.
12. Set the lathe centers straight, turn out the recesses, and finish-turn all the shoulders and the edge of the large pulley.
13. Finish-face the inner shoulders and the hub end.
14. Set the tail center over toward the front, and finish-turn the hub.
15. File the pulley faces smooth, and dull the edges. Inspect for exactness in the sizes, and for smooth and perfect finish. Polish the pulley faces bright with oil and emery cloth.

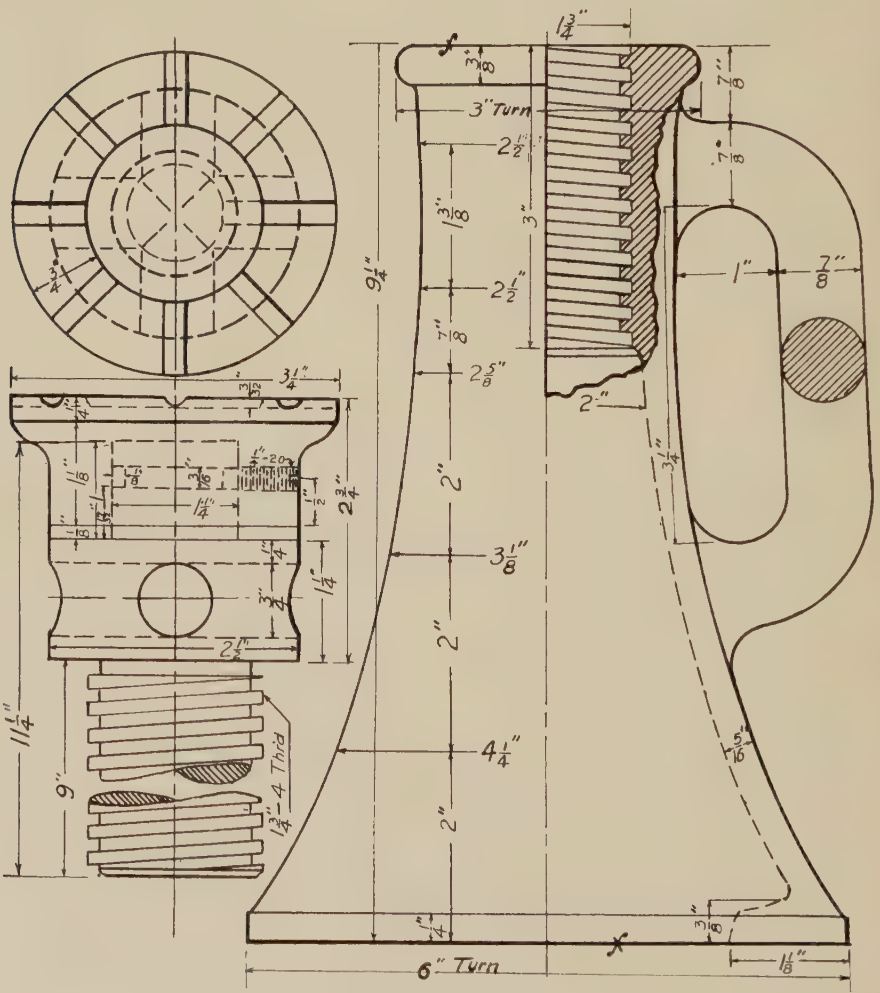
QUESTIONS

1. In making the mold for the casting, how should the pattern be placed in the flask?
2. How may the casting be adjusted to run true in the chuck?
3. How may the drill be started so as to bore a true hole?
4. Should all roughing cuts be taken before finish turning is begun? Why?
5. For a given taper, does the amount of set-over depend on the length of the mandrel?
6. If internal stresses are released by turning off the scale, will that affect the shape of the pulley flange? How?
7. How does the crown of a pulley aid in keeping the belt on?

Problem 96

HEAVY SCREW JACK

Subject and Uses: This jack is designed to have the maximum strength and efficiency in lifting power. It is suitable for raising buildings and heavy machinery, and for exerting great pressure. The base, made of cast iron, has a strong handle which is a great convenience in handling the jack. It also has ample base area in order to distribute the pressure over the support. The cap rests on a heavy brass washer and on a broad shoulder, to prevent any cutting of the steel when the screw is turned.



DETAIL OF HEAVY SCREW JACK

If material of the required size for the cap is not in stock, steel of the size required for the screw may be heated and upset to the diameter required for the cap.

This screw-jack project should be reserved until the student has had considerable experience in thread cutting. The inside and outside square-thread tools are forged and ground so that they have the required lead, clearance, and size. A micrometer caliper is used to take the exact measure of the widths of these tools. The inside thread tool should measure ⅛ in. in width, while the outside tool should measure .002 in. over ⅛ in. They are then hardened and tempered. A split pattern and core box, providing bars across the ends for centering and turning, are made for casting the base.

Object of Lesson: Making inside and outside square-thread tools; cutting square threads; making brass washer.

Tools and Equipment: Lathe; steady rest; boring, turning, and threading tools; chuck; drills; forge; sledge; files; micrometer caliper.

Materials Required: For base, one iron casting; for screw and cap, 2⅝-in. round machine steel, 14 in. long; for washer, ⅛-in. sheet brass, 2¾ by 2¾ in.; ¼ by ¾ in. headless setscrew.

Procedure:

1. Locate the centers on the cross bars of the casting for the base with a surface gauge; drill and countersink.
2. Mount the base on the lathe centers, face up the bottom, and turn up the outer rim.
3. Reverse the work, and grip the bottom rim of the base in the lathe chuck, with the top on the tail center.
4. Take a straight cut over the top rim to make a bearing for the steady rest.
5. Mount and adjust the steady rest to the top rim. Lubricate the rim. Remove the center cross bar by drilling a hole in each end of the bar.
6. Face the end. Bore out the hole to 1½ in. plus .010 in.
7. Cut a square thread to 1¾ in. diameter, 4 threads per inch. The depth of the thread should equal the width.
8. Make a cap and screw. Heat the end of the 2⅝-in. bar to a bright red, and upset it to 3½ in. diameter.
9. Center and mount this bar on the lathe centers. Face the end of the cap and turn it to shape.
10. Reverse the work. Mount the cap end in the chuck, and the screw end on the tail center.
11. Make three cuts with the parting tool, 1 7/16 in., 2⅜ in., and 3¾

in. respectively from the top of the cap end. The first two cuts should be 1¼ in. in diameter for the necking, and the third cut to 1½ in. diameter.

12. Rough-turn the screw, the shoulder, and the neckings.

13. Finish-turn these cylindrical parts, and face all shoulders as shown in the drawing.

14. Cut a square thread to a firm running fit in the base, and oil it freely.

15. Cut a groove in the necking, for the cap setscrew, to 1 in. in diameter, 3/16 in. wide.

16. Face the screw to the required length. Finish all parts of the screw, polish it, and cut it off from the cap. Leave the cap in the chuck.

17. Locate and drill two ¾-in. holes, at right angles through the shoulder of the screw.

18. Drill a 1¼-in. axial hole in the cap, ⅞ in. deep, and square up the bottom 1 in. deep to fit the top of the screw.

19. Face the cap. Finish and polish it all over and remove from chuck.

20. Grip the sheet brass for the washer in the lathe chuck.

21. With a narrow tool, cut out a 1-in. circular disc, and bore out a 1¼-in. hole.

22. Turn out the outer edge of the washer to 2½ in. diameter and finish it square. Cut it free from waste metal in chuck.

23. Fit the washer and cap on the screw necking. Measure and locate the setscrew on the cap, to fit groove in necking.

24. Drill a 3/16-in. hole in the cap, and tap it to ¼–20 thread. Shape one end of the screw to fit the groove in the large screw necking, and in the other end of setscrew make a saw cut for a screw driver.

25. Lay out and chip eight radial grooves in the top face of the cap, and finish off the grooves with a file.

26. Apply two coats of black enamel on the base. Assemble the parts to a perfect fit.

QUESTIONS

1. Why must the handle of the base pattern be split?
2. Is half a core box enough for the core of the base pattern? Why?
3. In coring for center bars, should the loose pieces be flush with the end of the pattern?
4. In removing the bars with the centers, should they be weakened by drilling before breaking?
5. How is clearance provided in the thread tool? May the angle of the lead be taken from the hypotenuse of the triangle, having the circumference of the screw as the base and the lead of the screw as the altitude?
6. How does the angle of the lead vary with the diameter of the screw for the same pitch?

Problem 97
TOOLMAKER'S VISE

Subject and Uses: The end blocks of this vise are fixed on the round rods in a drive fit, and the rods furnish the necessary guides for the movable jaw. The screw has left-hand Acme thread. It screws through the front end piece, and is held in a socket in the movable jaw by a pin, which is inserted through a hole in the jaw. This pin fits into a groove in the end of the screw so that the screw can be turned, but has no end play. The fixed jaw has vertical and horizontal V grooves cut in it to hold round stock. The advantage of an open base, when used on the drill press is that the drill may be run through the work without injuring the base. Also, long slender pieces may be gripped near one end with the rest of the piece hanging down through the base. The jaws are made square, so that by placing the vise on its side or end, holes may be drilled at right angles, in small pieces, without changing the work in the vise.

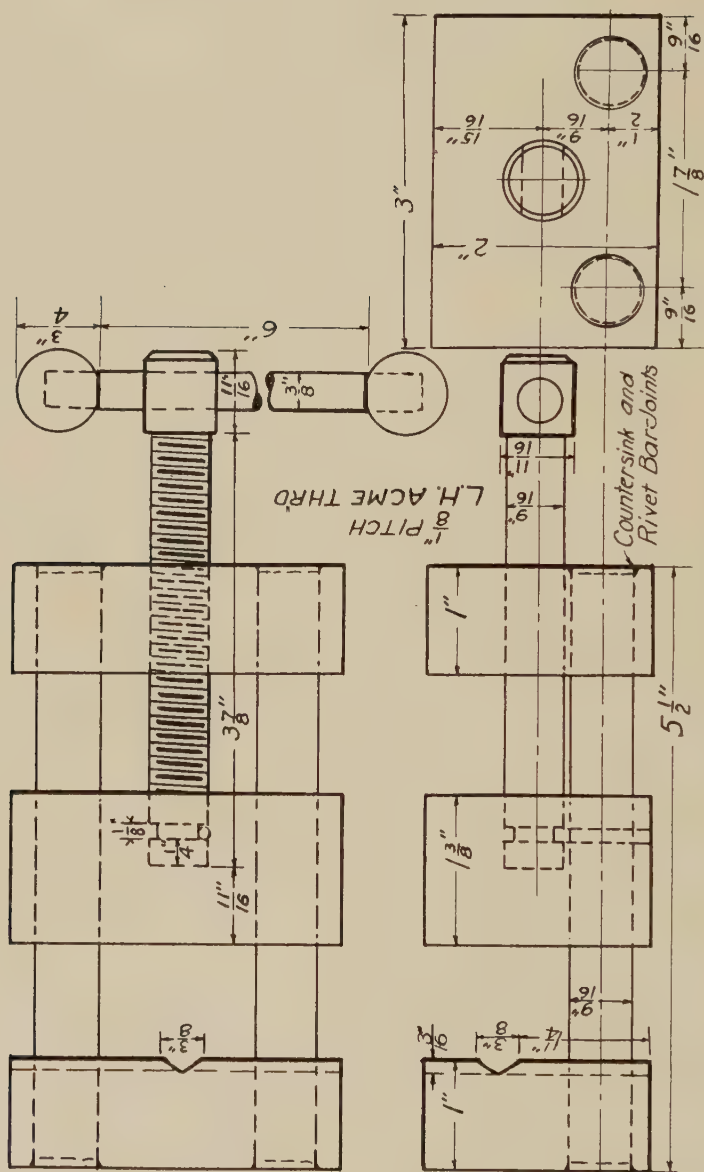
Object of Lesson: Exact drilling of duplicate parts; planing square blocks; cutting left-hand Acme thread; turning spheres.

Tools and Equipment: Shaper with vise; lathe with Acme threading tool; drill press; drills; reamer.

Materials Required: Iron blocks for jaws, two, $1\frac{1}{8}$ by $2\frac{1}{8}$ by $3\frac{1}{8}$ in., and one, $1\frac{1}{2}$ by $2\frac{1}{8}$ by $3\frac{1}{8}$ in.; machine steel $\frac{5}{8}$ in. round by $11\frac{1}{4}$ in. long, for base bars, and $\frac{3}{4}$ in. round by $6\frac{1}{2}$ in. long for screw and spheres; for handle, $\frac{1}{2}$ in. round by 7 in. long; for pin, $\frac{1}{8}$-in. wire, $1\frac{1}{4}$ in. long.

Procedure:

1. Plane up the end-piece faces parallel and to dimensions.
2. Plane the movable jaw faces, parallel and to dimensions.
3. Clamp the three pieces together in the vise, and plane the sides and ends square with the faces.
4. Plane 90-deg. V grooves lengthwise and across the face of the fixed end jaw, to dimensions.
5. Lay out holes for the base bars and for the screw, in the front end piece. Copper-coat the metal and use a surface gauge. Center-punch the points. Draw a $\frac{1}{2}$-in. circle around each point and mark it by eight center-punch marks.
6. Drill a $\frac{1}{8}$-in. hole, $\frac{1}{2}$ in. deep at each point, and run a $\frac{1}{4}$-in. drill clear through. This first block will serve as a template for drilling the other two pieces by clamping it to one of them in turn, in the vise, in the relative position which they will occupy when assembled.
7. Drill all holes $\frac{1}{4}$ in. for the base bars in the three pieces, and for



DETAIL OF TOOLMAKER'S VISE

the screw through the front end piece and into the movable jaw, 11/16 in. deep.

8. Hold the front end on the fixed end, and drill 35/64-in. holes for the base bars. Replace the fixed end by the movable jaw and drill it for the base bars. Drill also 7/16-in. holes for the screw, through the front end and into the movable jaw, 11/16 in. deep.

9. Drill a screw hole in the movable jaw separately with a 9/16-in. drill, 11/16 in. deep, then counterbore to a flat bottom.

10. Ream holes for the bars in the movable jaw with a 9/16-in. reamer.

11. Tap out the screw hole in the front end piece with a left-hand Acme tap, 9/16 in., 1/10 pitch.

12. Center and turn two base bars to fit the reamed holes in the movable jaw.

13. Polish the bars and turn the ends to make a press fit into the end pieces. Countersink the outer ends of holes for the base bars, 3/32 in. deep.

14. Grip the stock for the screw in the lathe chuck, drill a 3/8-in. axial hole 1/2 in. deep in one end of the stock. Then turn up one of the 3/4-in. balls for the end of the handle, cut off the ball when finished, and repeat the operation for the other ball.

15. Another method: Drill a 3/8-in. hole in each end of the stock, turn up a 3/4-in. sphere at each end of the stock, and finish. The balance of the stock can be used for the screw.

16. Center the stock for the screw, turn the head and the shank, square up the ends, and chamfer.

17. Cut the thread to fit the tapped hole in the end block.

18. Cut a 1/8-in. groove, 13/32 in. diameter, for the pin.

19. Drill a 3/8-in. hole through the head of the screw, for the handle; finish the screw completely.

20. Center and turn the handle to press fit into the spheres at each end.

21. File the handle between the spheres, and ream out the hole in the screw to a sliding fit.

22. Assemble the vise and rivet ends of base bars, file flush and polish. Locate and drill a hole for the pin in the movable jaw.

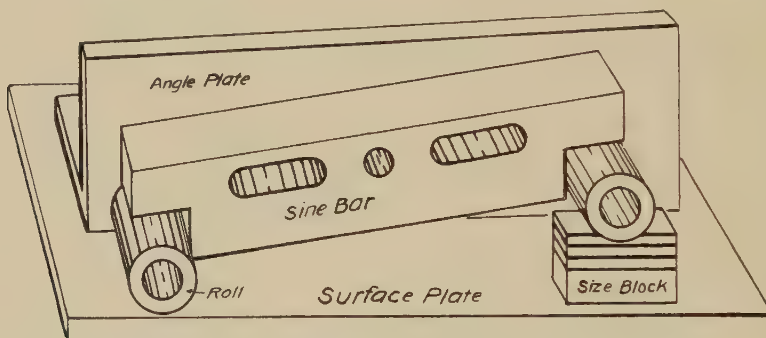
23. Fit the pin in place. Adjust all parts to a smooth working condition.

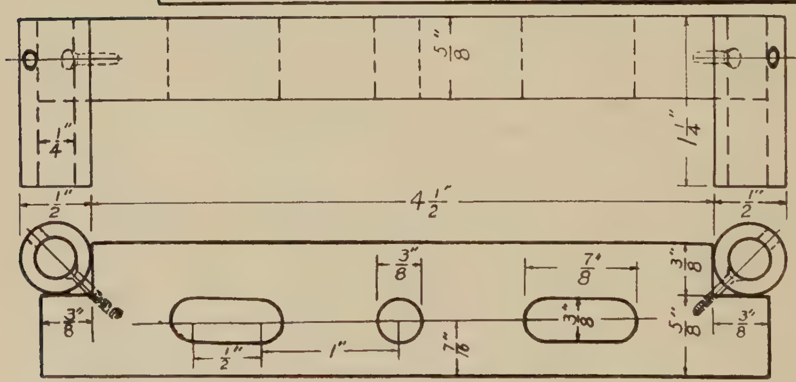
QUESTIONS

1. Why is a left-hand thread preferable at certain places to right-hand?
2. How does the Acme thread differ from the square?
3. In what particulars is the Acme thread superior to the square?
4. Is the Acme thread preferable to U. S. standard? Why?
5. Is the Whitworth thread superior to U. S. standard? Why?
6. Why is the sharp V thread so much in common use?

Problem 98
SINE BAR

Subject and Uses: A sine bar is used a great deal in machine work, especially in the toolroom. It generally is set up on an angle plate to the required angle, and is bolted in position. The work then may be clamped securely in place in direct contact with the sine bar. It is a great time-saving device for accurately setting up work that must be drilled, planed, or milled to a specified angle.





DETAIL OF SINE BAR

The method by which the bar is set to the desired angle is to find the sine of the angle, and then multiply that number by the distance between the centers of the rolls on the sine bar. This product gives the distance that one of the rolls must be raised to set the sine bar to the required angle. A good way is to let one roll rest on a surface plate, place the size blocks to the desired height under the other roll, and then strap it to the angle plate.

In this sine bar, the rolls are 5 in. between centers. If we wish to set the bar to an angle of 10 deg., we must turn to a table of sines in a hand-

book. The sine of 10 deg. equals .17365 which, multiplied by 5 in., amounts to .86825 in. plus the thickness of a piece of writing paper, or 7/8 in. Therefore, placing one roll directly on the surface plate, and the other on 7/8 in. of size blocks plus a thickness of paper, the bar makes an angle of 10 deg. with the plate. By this process, the bar may be set to any angle, and the work may be aligned to it and machined to specifications.

When practicable, the parts of the sine bars are machined, pack-hardened, and ground to dimensions. However, with care in handling, the bar will give long service when merely machined and finished to exact size.

Object of Lesson: Planing; scraping; turning; measuring; finishing; assembling to a high degree of exactness.

Tools and Equipment: Planer or shaper; scraping tools; lathe; drills; turning tools; files; micrometer caliper.

Materials Required: Bar machine steel, for sine bar, 3/4 by 1 1/8 by 5 1/2 in.; for rolls, round machine steel, 5/8 by 3 in.; 2 No. 5 flat-head setscrews.

Procedure:

1. Select the steel for the bar, and cut to size.
2. Plane the sides, faces, and ends, square, and to dimensions, 5/8 by 1 by 5 1/4 in.
3. Cut away the top corner at each end, 3/8 by 3/8 in., exactly 4 1/2 in. apart when finished.
4. Lay out, drill, cut out, and file the bolt openings, for clamping the bar to the angle plate.
5. File and scrape the bar all over to true flat surfaces, exactly to dimensions, and square.
6. Center the stock for the rolls, mount it on the lathe centers, and turn it to 17/32 in.
7. Finish turn, file, and polish the rolls smooth, to measure .500 in. all over.
8. Drill a 1/4-in. axial hole through the rolls.
9. Drill a 1/4-in. transverse hole, 3/8 in. from each end, 7/16 in. deep.
10. Drill these holes through the rolls, and countersink them to fit No. 5 screws.
11. Drill a hole in each end of the sine bar, bisecting the square angle and equidistant from the faces, and tap it to fit a No. 5 screw.
12. Cut the rolls into two equal parts, and fasten each into place on one end of the sine bar.
13. Mark the short end of the roll flush with the face of the sine bar.

14. Remove the roll, insert it in the lathe chuck, grip it without bruising, and face end exactly to the flush mark.

15. Face the second end of the roll to a 1¼-in. length. Assemble, inspect, and finish the bar.

QUESTIONS

1. Since the sine of an angle is the ratio of the altitude to the hypotenuse of a right triangle, which part of the triangle is the sine bar?
2. Would the sine bar serve as well if it were 10 in. long? 20 in.? 10¼ in.?
3. How may work be aligned to the angle of the sine bar without being in direct contact with it?
4. Why is it necessary that the two rolls be parallel, be spaced apart exactly to dimension, and be equally spaced from the long side of the sine bar?

Problem 99

V BLOCKS

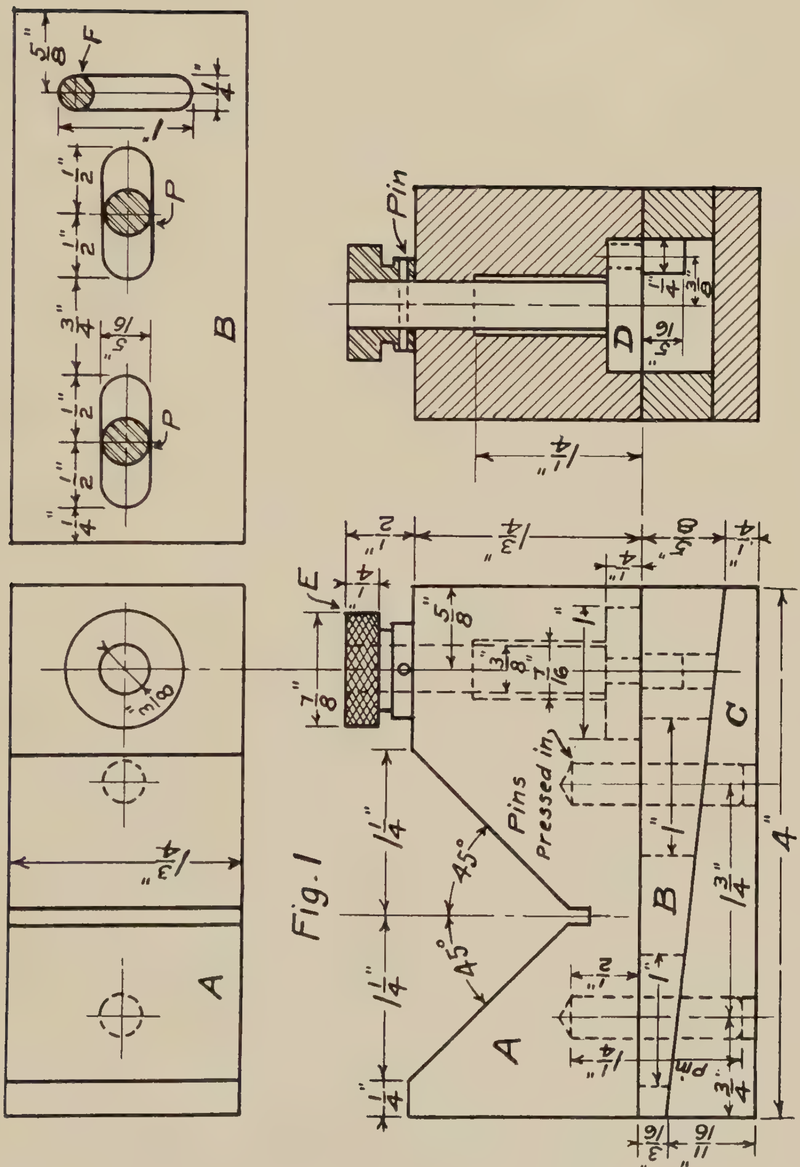
Subject and Uses: A V block is used for holding or laying out cylindrical work. It also may be used as a support for work which is held on a mandrel in aligning it on the planer table. Figure 1 shows a V block which is adjustable in height. This proves to be a great advantage when a cylinder is to be aligned, the ends of which have different diameters. The top view B, of Figure 1, shows how wedge B is guided by two pins P that slide in two slots, when eccentric pin F is turned. This pin slides in the transverse slot, and moves the taper block B endwise. The pins P are fixed in block A, pass through slots in B and into block C, where they have an up-and-down motion as block B is moved to the left or to the right. Thus the V block is adjusted up and down by turning the knurled nut E, which is pinned to the spindle that is a unit with disc D containing the pin F, which moves the taper block B endwise.

Figure 2 shows another V block provided with clamps for fastening down cylindrical work of different sizes. The hook bolts which hold down the yokes Y are readily removed, when the V clamps are to be fastened down on long spindles. The space between the two clamps affords ample opening for the drill chuck and, where holes are drilled clear through the cylinders, the clearance below the work allows the drill point to come through without damaging the block. This V block may be made from a piece of steel. It is planed on the shaper, hardened, and ground. The bottom is relieved across the middle, so that the bearing surfaces are confined to the ends.

Object of Lesson: Practice in operating the shaper; planing angles; cutting slots; planing sloping surfaces; making spindles and thumb nuts.

Tools and Equipment: Shaper; lathe; drill press; drills, turning, knurling, and threading tools; cape chisel; file.

Materials Required: Figure 1: iron castings for blocks A, B, and C;



DETAIL OF V BLOCK ADJUSTABLE IN HEIGHT

for nut E, spindle, and disc D, 1 in. round machine steel by 3 in.; for pins P, 5/16 by 3-in. drill rod; for crank pin, ¼ by ⅝-in. drill rod, 1/16 in. by ¾ in. for pin.

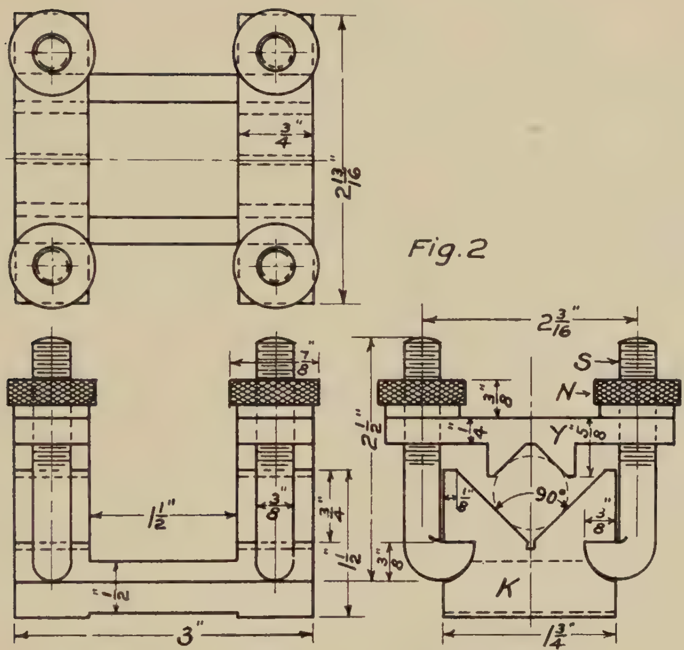
Procedure:

1. Plane blocks A, B, and C as shown in the drawing. Plane the top and the bottom of each block separately, then clamp the three together in the required position, and plane the sides and the ends square.
2. Lay out and drill holes in A for pins P, and for the spindle joining E and D. Counterbore for disc D.
3. Lay out and drill a series of holes for each slot in B, perpendicular to its top surface, cut them out with a chisel, and file them to size and to a smooth shape.
4. Lay out and drill two holes in base block C, to match the holes in A.
5. Grip 1-in. steel for nut E in the lathe chuck, and turn out E to size. Then knurl it, drill a ⅜-in. hole, 9/16 in. deep. Then cut the nut off ½ in. long.
6. Center the remainder of the stock. Mount it on the lathe centers. Turn the spindle to ⅜ in., and the disc to a running fit in the counterbored recess in block A.
7. Drill a 7/32-in. hole in disc D, ⅜ in. from the center. Fit and press pin F into place in disc D. Fit the spindle into block A and nut E. Drill a 1/16-in. hole through nut E and the spindle for the locking pin. Assemble these parts to fit in position.
8. Finish pins P and press them into block A. Assemble the three blocks, and make adjustments until the parts work properly together. Finish all parts to smooth, perfect surfaces. Test the assembled block for squareness.

Materials Required: Figure 2: for V block, 1¾ by 2 by 3¼ in. machine steel; for yokes, ¾ by 1 by 6 in.; for hook bolts, ½ in. round by 12 in.; for nuts N, 1 in. round by 4 in.

Procedure:

1. Figure 2 is made by planing V block K to the dimensions shown in the drawing. It is then casehardened and ground square.
2. To make yokes Y, plane the stock to a rectangular prism, ⅝ by ¾ in.
3. Cut the rectangular prism in two and, holding the pieces together, square the ends to length.
4. Plane across the pieces, shaping the 90-deg. V yokes and the adjoining flats.



DETAIL OF V BLOCK PROVIDED WITH CLAMPS

5. Lay out and drill 25/64-in. holes in the yokes, 1 3/32 in. on either side of the center.

6. Grip the stock for the nuts in the lathe chuck. Drill a 9/32-in. axial hole, and tap it for 3/8-in. 16 bolts.

7. Turn it down to 7/8 in., and knurl. Turn down the shoulder to 3/4 in. Face the end. Cut off the nut 3/8 in. long. Make four nuts.

8. Cut off stock for four hook bolts, each 3 in. long.

9. Heat the end to bright red, upset, and form it to hook shape.

10. Center the end true to the axis and mount it on the lathe centers.

11. Turn the stock to 3/8 in., face the hook, square, and cut 16 threads to fit nut N.

12. Finish the bolts by filing the hook. Fit the parts together, and assemble.

QUESTIONS

1. Why are the V blocks shaped to a 90-deg. angle?
2. To what angle is the shaper head set, for planing the sides of the angle?
3. How may V block be made to serve in place of centers on a planer?
4. What makes the V block suitable for locating the centers in irregular stock?
5. Name the different uses for which the clamping V block is adapted.

Problem 100-A
BENCH AND DRILL-PRESS VISE

Subject and Uses: The style of vise shown in the accompanying drawing may be made without special fixtures, requiring for its construction only a lathe and a shaper. It is of average size, and is strong, and suitable for holding a great variety of work. Moreover, the pattern and foundry work present no such difficulties as would be beyond the capacity of the apprentice who has had a fair amount of preliminary training. The machine work involved in finishing the several parts of this vise is a source of valuable experience to the earnest student.

Object of Lesson: Planing; drilling; tapping; cutting Acme thread; making bushing.

Tools and Equipment: Shaper; lathe; Acme tap; counterbore; drills, 1-in. 24 U.S.S. left-hand tap.

Materials Required: Iron casting of vise base and jaw; machine steel for jaw plate, ½ by 1½ by 2¾ in.; round machine steel for screw, washer, handle balls, and bushing, 1 in. by 11 in.; for handle, round machine steel 7/16 by 4¾ in.

Procedure:

1. Secure the proper castings made of a good quality of iron, and free from hard spots. Clean the castings and make them smooth before taking them to the shaper.

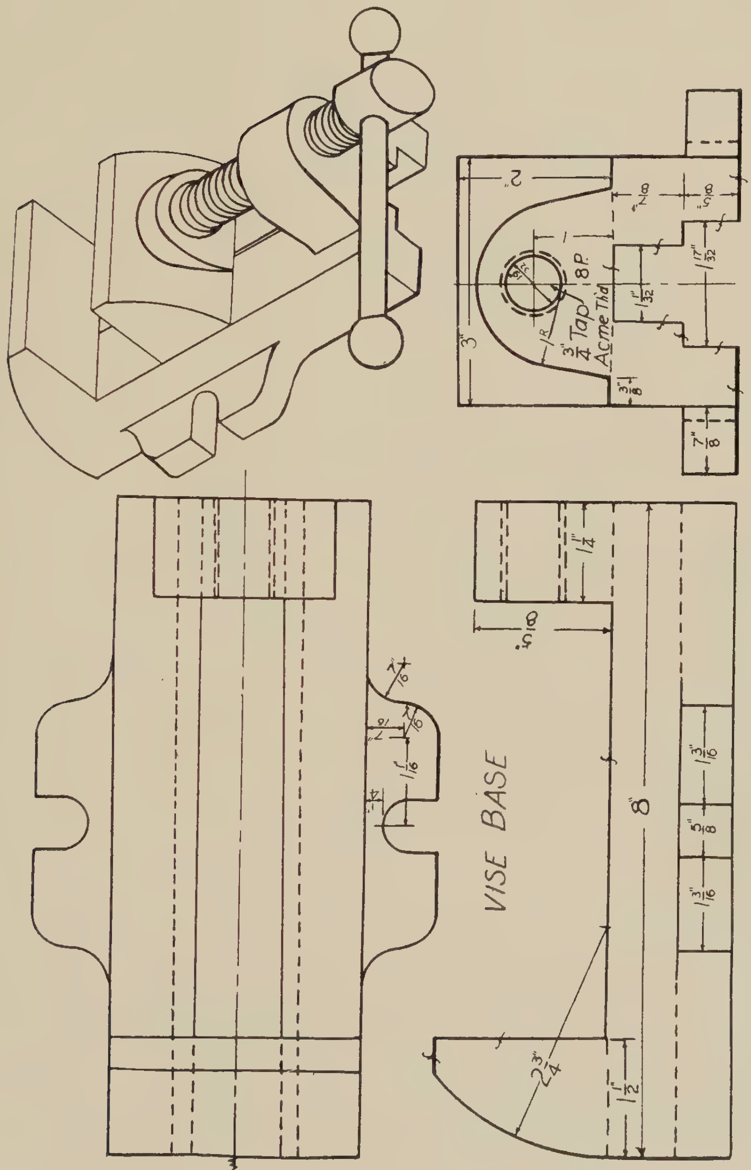
2. Fasten down the vise base, and plane the bottom and the longitudinal groove, leaving 1/64 in. of stock all over for finishing. With a finishing tool, finish-plane the faces to the required size.

3. Turn the work right side up, and fasten it down to rest on the finished base with the bottom groove at right angles to the planer stroke. Plane the top face of the base, the top edge of the jaw, and the face of the jaw square with the base. Take a finishing cut.

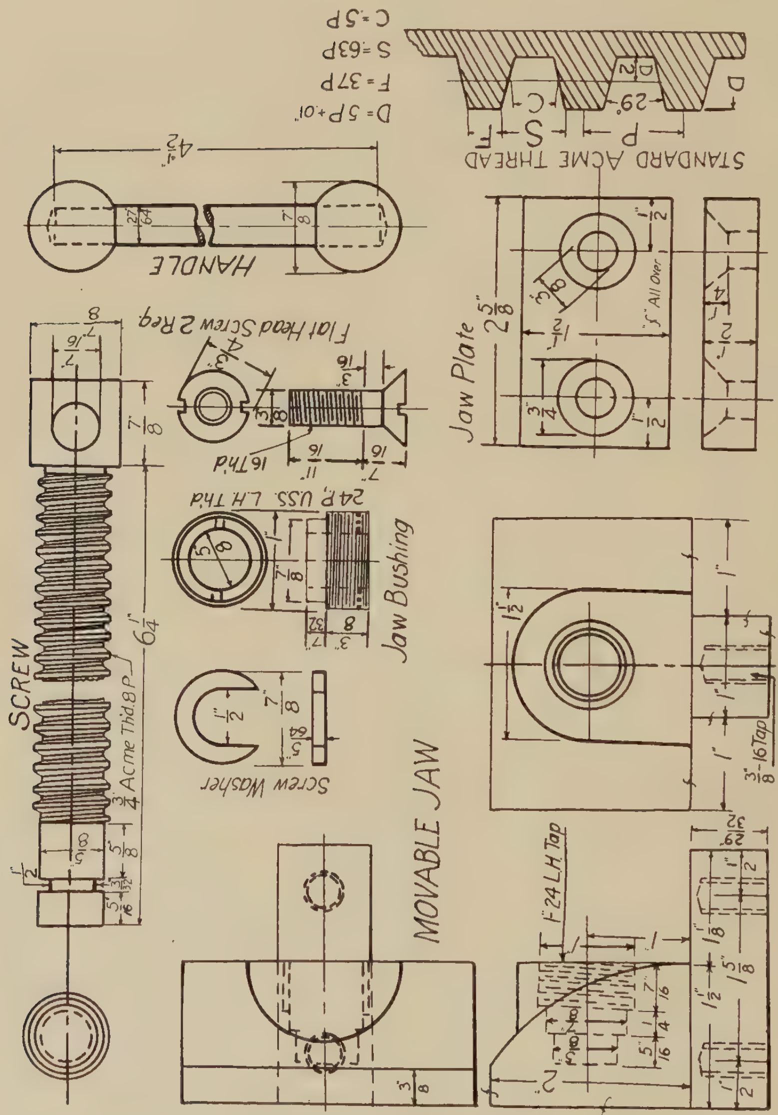
4. In planing the movable jaw, grip its sides in a vise and finish the face, being careful that the base of the jaw is square.

5. The base of the jaw is then planed square with the face, and accurately to dimensions, so that it will make a sliding fit in the opening of the vise base. The top of the jaw is planed parallel with the bottom and to dimensions.

6. The hole in the vise base for the screw may be drilled in a lathe, on centers. With a surface gauge, lay off and center-punch both ends of the base. Drill a hole for the ¾-in. tap, holding the work against the dead center in line with the planed faces. The size of the hole to be drilled for an Acme thread, 8 pitch, is ⅝ in. The hole is started with smaller drills, as usual.



DETAIL OF VISE BASE



DETAIL OF MOVABLE JAW

7. The movable jaw may be drilled together with the vise base, by clamping the jaw in place on the base, and running the drills clear through the boss and into the jaw. The finishing of this hole is done separately. The bottom is squared up with a 5/8-in. counterbore, and the outer part of the hole is enlarged with a 7/8-in. drill for the small end of the bushing and for the screw washer. The mouth of the hole is drilled to fit the tap for the threaded part of the bushing.

8. In tapping these holes, it is well to start the tap on the centers to insure true alignment, which is essential in order to have the screw move the jaw with the least amount of friction.

9. The jaw plate is planed to dimensions, holes are laid off, center-punched, drilled, and countersunk.

10. Holes are laid off and drilled in the bottom of the movable jaw guide, and are tapped for the two cap screws.

11. Get a piece of round machine steel, 1 in. in diameter and 11 in. long. Grip it in the lathe chuck, and make the two spherical knobs for the handle. Drill holes 5/8 in. deep and 27/64 in. in diameter to make a shrink fit on the handle. Turn, file, and polish them to a bright finish.

12. To make the screw washer, face the end of the steel, drill a 1/2-in. hole, turn it down to 7/8 in., polish and cut it off 5/64 in. thick. Saw out a part of the washer, as is shown in the drawing, and file the opening to the dimension required.

13. Make the bushing by drilling and reaming a 5/8-in. hole, 5/8 in. deep. Turn down to 7/8 in. for a length of 5/32 in. True up and cut a left-hand thread to fit into the threaded hole in the movable jaw. Polish and cut off 5/8 in. long. On the threaded end, make screw-driver slots, with a saw and a file, to accommodate a heavy screw driver.

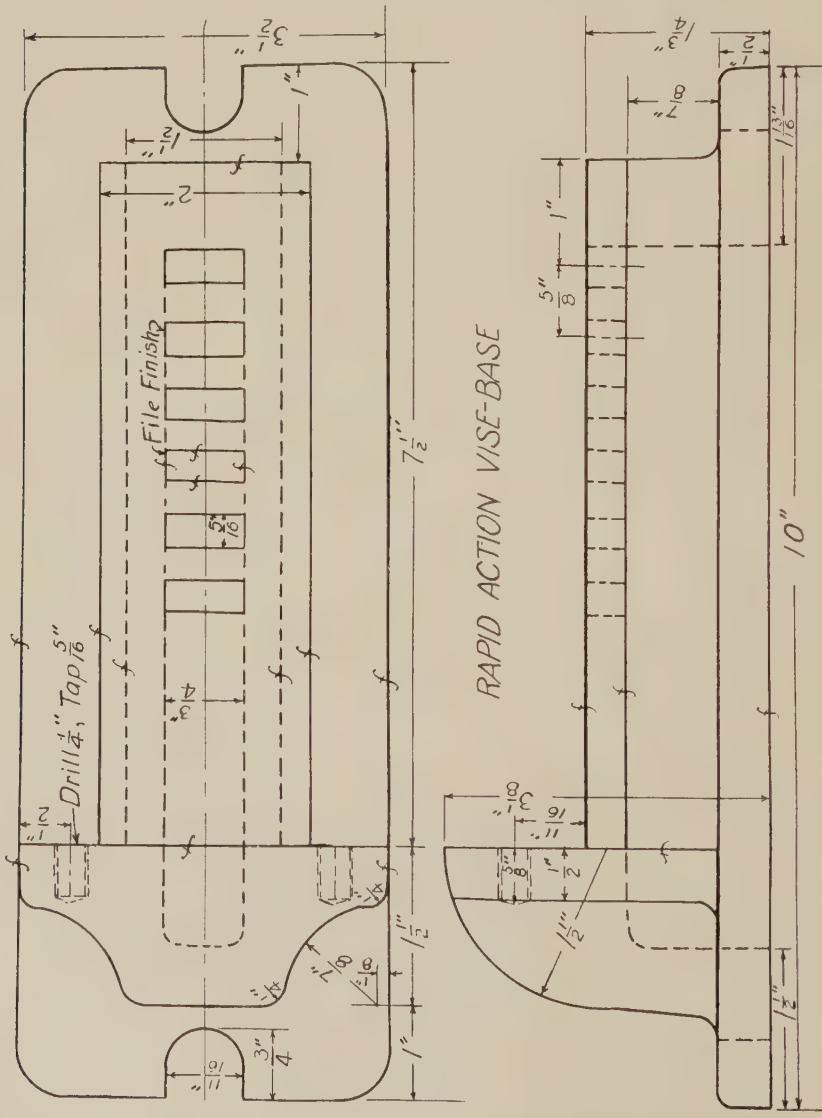
14. Make the screw by centering a piece of steel of the proper length in the lathe. Turn it down to 7/8 in. With a 1/8-in. parting tool, cut the necking to 21/32 in. diameter. Turn the shank for the 3/4-in. screw. Gear up the lathe, and grind and set the tool in preparation for cutting an Acme thread, 8 pitch. Bear in mind that the Acme is similar to the square thread, in that the depth of the thread is equal to half the lead, but differs in this, that the sides of the Acme thread make an angle of 29 deg., while those of the square are parallel. The Acme thread tool requires careful grinding. The angle of the sides is 29 deg., the width of the flat point for 1/8 pitch is .3707/8 minus .0052 or .0412, and the flat on top of the thread equals .3707/8 in.

The thread is cut to the required depth and is fitted to the tapped hole in the boss of the vise base. In testing the screw for a fit, use oil freely lest the screw should jam.

15. Having finished the threads, turn down the end of the shank to 5/8 in. for a close-running fit in the bushing. A few strokes with a smooth file should suffice to secure the required fit.

16. With a parting tool, 3/32 in. thick, cut the groove for the washer, as is shown in the drawing.

17. Drill a hole through the head of the screw for the handle, holding it against the V groove in a drill pad or in a drill vise.



DETAIL OF VISE BASE

18. Fit the handle through the hole in the screw so that it will slide, and fit the two knobs on the handle, or rather, file the handle for a shrink fit. Heat the knobs until they expand enough to push the handle into place, and let them cool.

19. The vise is ready for assembling. This means that all parts will receive a final retouching. Sharp edges and corners must be removed. Every piece must be inspected and, if necessary, altered to get a better fit, smoother action, or to improve the appearance. The machined metal surfaces which are exposed, should be finished smooth by filing, scraping, and then polishing with oil and fine emery. The jaw is fastened in place with two cap screws through the plate. It should slide freely with no perceptible play when the screws are set. The screw is put through the boss. The washer and bushing, having been fitted into the jaw previously, are slipped on the screw. The threaded end of the bushing is placed next to the thread of the screw. The washer is placed in the groove, and oiled. The bushing is then screwed into the jaw, and put in working condition.

All rough cast-iron surfaces should receive two coats of black paint.

Problem 100-B
RAPID-ACTION BENCH VISE

Subject and Uses: This vise may be used on the drill press, the bench, or on the milling machine. It has a quickly adjustable jaw for work of different sizes. By means of a stop nut having a projection that fits into any one of several square holes in the vise base, the screw passing through it is readily adjusted to bring pressure against the movable jaw and thus clamp the work. Patterns are to be made of the vise base, core box, movable jaw, and stop nut, and from these, forms for castings are to be molded.

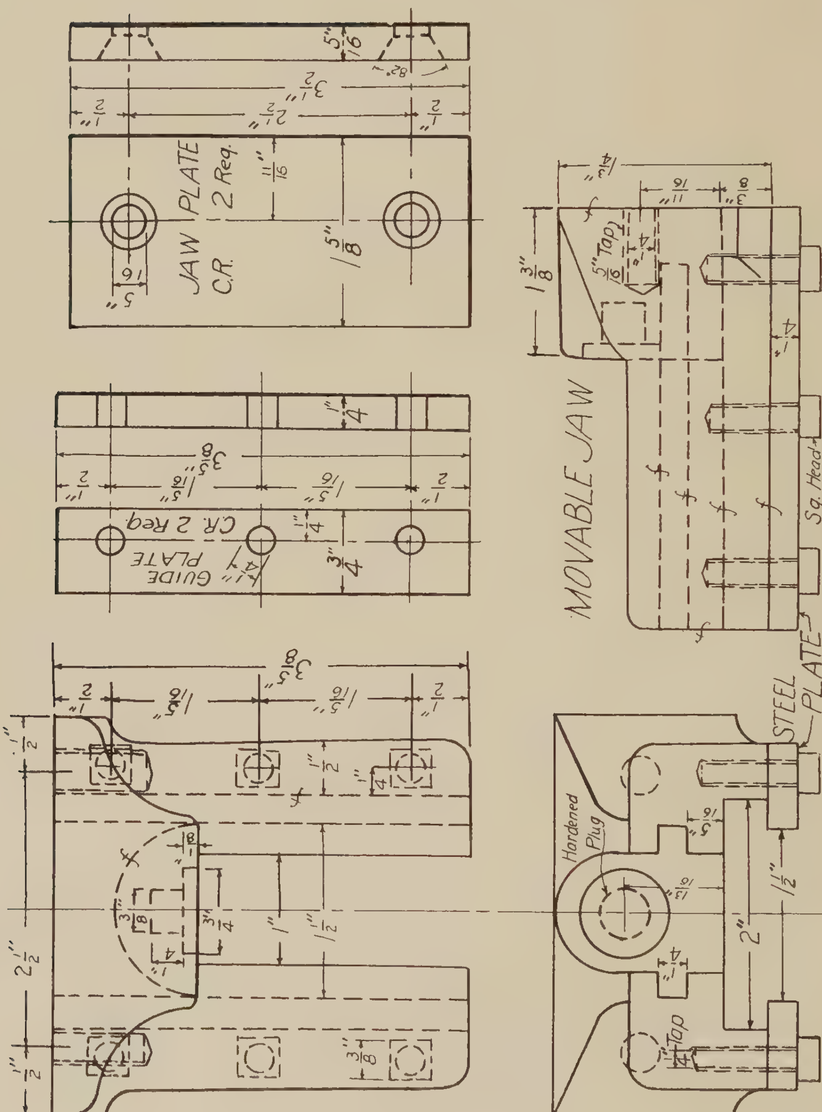
Object of Lesson: Planing; milling; screw cutting; drilling; tapping.

Tools and Equipment: Shaper; milling machine; lathe; tools.

Materials Required: Iron castings for vise base, movable jaw, and stop nut; for jaw plates, machine steel ⅜ by 1¾ by 7½ in.; for guide plate, ⅜ by ⅞ by 7¾ in.; for screw, ¾-in. hexagonal machine-screw stock, 4¼ in. long; for handle, ⅝-in. square machine-screw stock, 3¾ in. long; for plug, ⅞-in. tool steel, ½ in. long; for stop-nut pin, ¼ by 1½-in. drill rod; for pin through handle, 3/16 by ¾-in. drill rod; six square-head machine screws, ¼ by 1 in.; four countersunk screws, 5/16 by ⅞ in.

Procedure:

1. Have castings made as required; inspect them for quality; clean and smooth them preparatory to machining.



DETAIL OF MOVABLE JAW

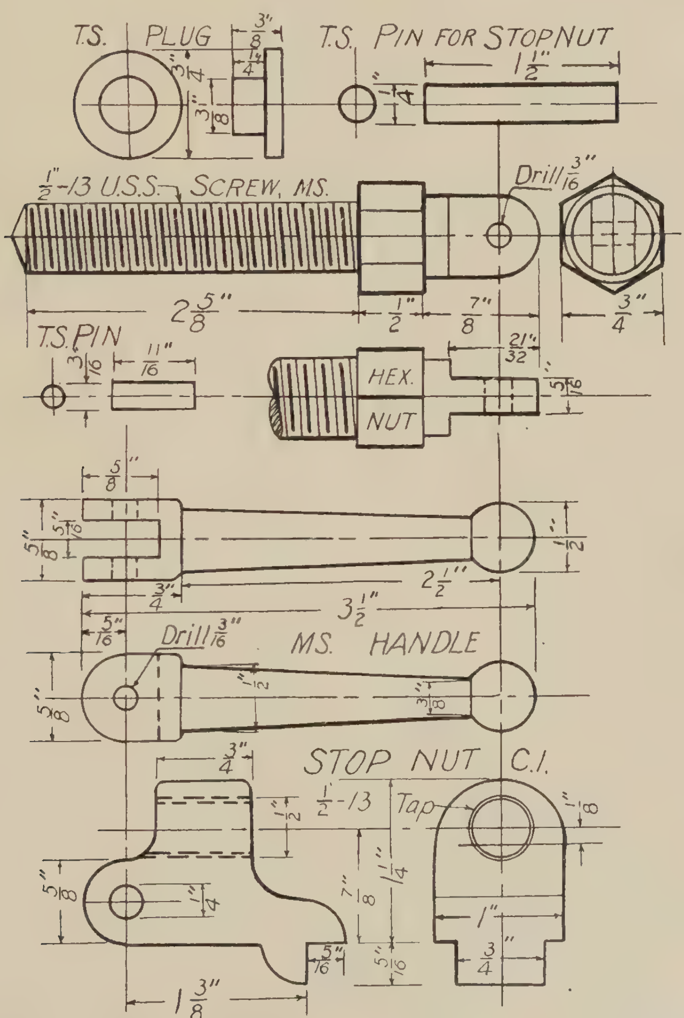
2. Fasten vise base in the shaper and plane the bottom, the top surface, the sides, and the face of the jaw.

3. Fasten the movable jaw in the shaper to plane the base and the recess that fits on the base.

4. Readjust the work and plane the jaw face and the rear end.

5. Fasten the work down on the jaw face, square up and plane between the two rear projections, square the face for the plug seat.

6. Lay out, drill, and counterbore for the plug.



DETAIL OF STOP NUT

7. Place the work in the milling machine, and mill out the slots in the two rear projections for the stop-nut pin to slide in.

8. Plane to dimensions the two jaw plates and to the two guide plates; lay out and drill the holes, and countersink the jaw plates.

9. Drill and tap the holes in the vise base and in the movable jaw as shown in the drawing, and fit the plates in their respective places.

10. File the stop nut to fit into place; drill holes for the pin and the screw; tap for the screw and press the pin into place.

11. Center stock for the screw accurately; turn up both ends to dimensions on lathe centers. Remove the work to the milling machine; mill the flat sides to form the projecting link that fits between the prongs of the handle. Remount the screw on lathe centers and cut the thread to a close running fit in the stop nut. Shape both ends and drill for the pin. (See drawing.)

12. Center the stock for the handle; turn to shape and dimensions; cut out a slot in the large end with milling cutter to fit on the end of the screw; locate and drill the hole for the pin; fit the handle on the screw; put the pin in place; rivet the ends slightly; file and fit the joint to work easily.

13. Grip in the lathe chuck a piece of 7/8-in. tool steel; turn up the plug to a press fit; fit the plug into its place in the movable jaw; cut it off square; finish smooth, harden in oil and press into position.

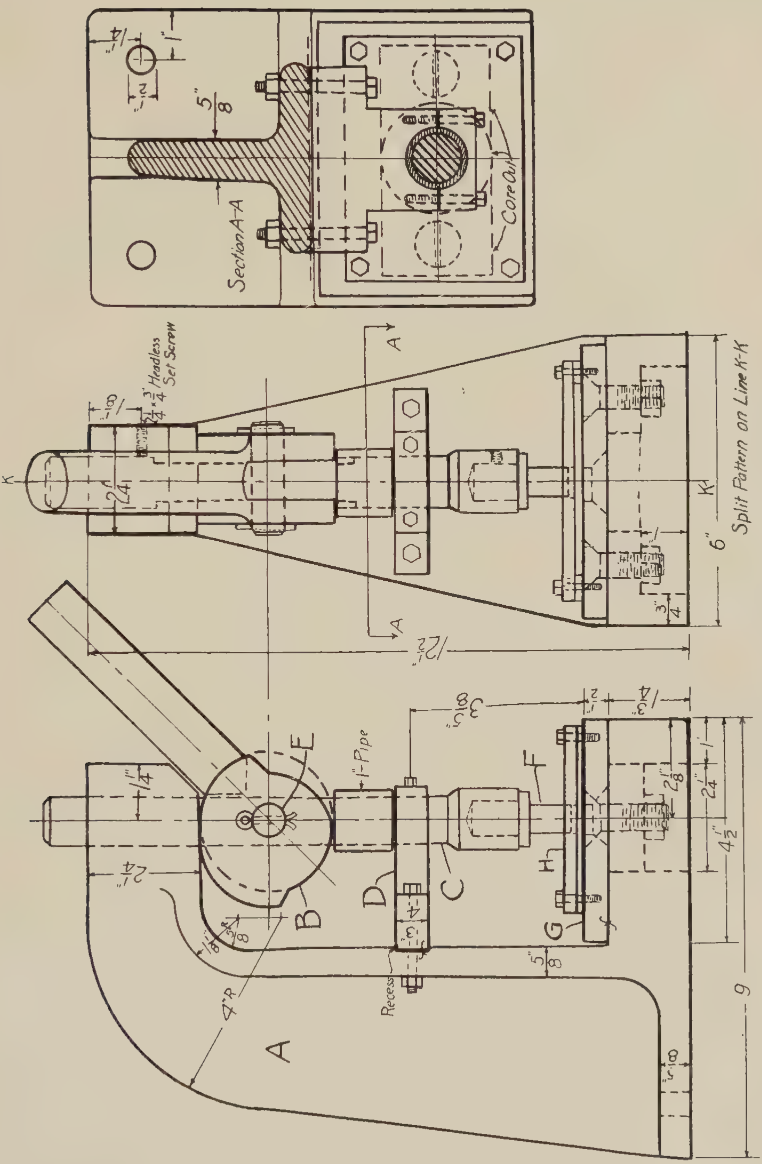
14. Inspect the separate parts carefully; file and polish bright to make a perfect fit and finish; apply two coats of black paint on the unfinished surfaces; assemble all parts so that the vise works perfectly, and is well finished in every detail.

Problem 101
PUNCH PRESS

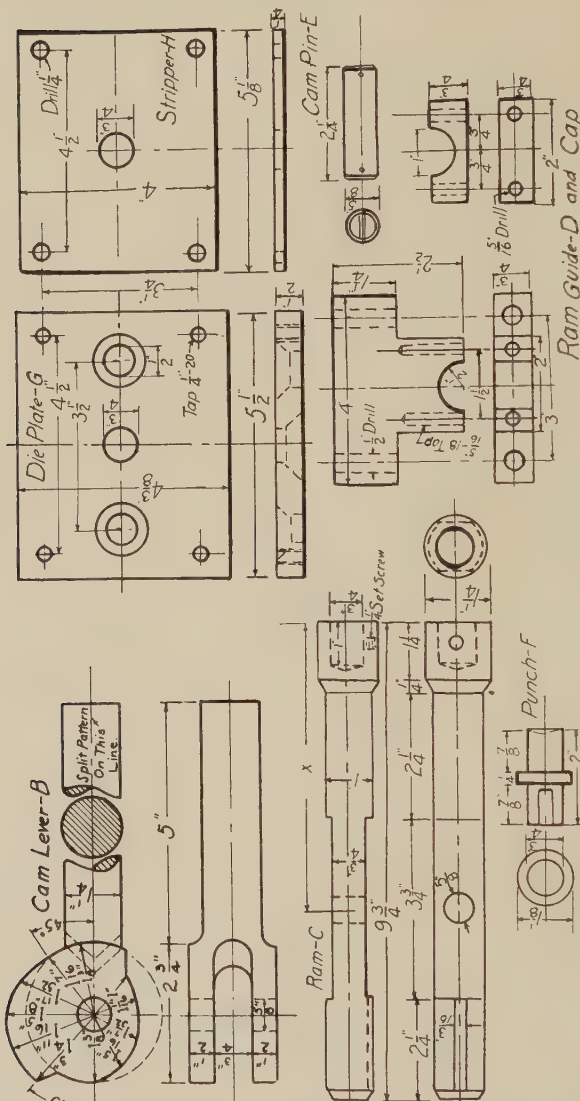
Subject and Uses: A punch press is a device for developing great pressure on a ram into which a punch is fastened. The punch, when lowered, fits into a die plate, and is used for shearing or punching sheet metal. The punch and die are made to the shape and size required for cutting the necessary sheet-metal shapes, such as washers or laminations for armature of electric motors, etc.

The principle used in this press for increasing the leverage is the cam. This is more suitable for a hand punch than the eccentric shaft used on larger presses.

Object of Lesson: Practice in making split pattern with core; laying out and shaping cams; turning and shaping ram, punch and die; hardening and tempering.



DETAIL OF PUNCH-PRESS FRAME



DETAIL OF CAM LEVER AND RAM GUIDE

Tools and Equipment: Lathe, shaper, and drill press with tools and drills.

Materials Required: Cast steel frame for press; cast steel cam lever; ram, 1⅜-in. cold-rolled steel, 10 in. long; ram guide, ¾-in. cold-rolled plate, 3½ by 4 in.; pin, ¾-in. round machine steel, 2½ in. long; 1-in. pipe, 1¾ in. long; die plate, ½-in. T.S. plate, 4½ by 6 in.; stripper C.R.S.,

¼-in. plate, 4 by 5¼ in.; punch, 1½-in. round T.S., 3 in. long; 2 bolts, ½ by 2½ in. (to fasten ram guide to frame); 2 guide cap screws, 5/16 by 1½ in.; 2 flat-head bolts, ½ by 1¾ in.; 4 cap screws, ¼ by ¾ in.; 2 headless setscrews, ¼ in., one ⅜ in.; 2 cotter pins.

Procedure:

1. The Pattern. — Make pattern of the press frame and cam lever allowing for shrinkage and for finish. The base of the press frame is cored out as is shown in the drawing by dotted lines, rectangular from the bottom up for an inch and cylindrical from there clear through.

2. The Casting. — Have steel castings made from patterns, and have them annealed.

3. Frame. — Finish the die seat by planing, or grinding and filing. Similarly, finish the recess for the ram guide, and drill two holes for the bolts to fasten the ram guide, two holes in the die seat for fastening the die, and two holes in the base for fastening the frame to the bench. Drill a 63/64-in. hole, ream 1 in. for the ram, drill 3/16 in. and tap ¼ in. for the setscrew, flattened to fit into the slot in the ram.

4. Cam Lever. — The cam serves for lowering and raising the ram, and must be finished accurately to dimensions. A sheet-metal template, shaped exactly to line will aid in this. The ⅝-in. hole is located and drilled in the cam. A ⅝-in. button on the center of the template will serve in marking the cam, first on one side and then changing the button to the other side of the template; the second side of the cam is outlined to correspond with the first. The cam is then filed down to line, the diameter being a constant, 2¾ in. in this case, but the radius, a variable, from 1 in. to 1¾ in. The movement of the ram is, accordingly, ⅜ in.

5. The Ram. — Center 1⅜-in. round stock, 10 in. long, and turn to dimensions. The two flat sides are cut in the shaper or milling machine, and the keyway, 3/16 in. wide and ⅛ in. deep, is cut likewise. This work can also be done with a chisel and file if necessary. Drill a ¾-in. hole for the punch, and drill and tap for the setscrew.

6. The Guide and Cap. — The parts, made as one piece of cold-rolled steel, are sawed to shape and drilled and bolted to the frame. The ram is put in place, and the hole for the ram is scribed, centered, and drilled 63/64 in. and reamed 1 in. Holes for the cap screws are drilled 5/16 in., ⅞ in. deep, and continued 1 in. deeper with a ¼-in. drill and tapped 5/16 in.—18. Cap and guide are then sawed apart, and shims inserted between them.

7. The Cam Pin. — This pin is cut to the correct length from ⅝-in. cold-rolled steel in the lathe chuck, is chamfered, and a ⅛-in. cotter hole is drilled at each end.

8. The Punch. — Punches and dies of different sizes are made from time to time as wanted. They are made of tool steel. The upper end is turned and flattened to be held in the ram. The shoulder takes up the thrust. The lower end is turned concave to give a sharper edge and to facilitate sharpening. The punch and die are hardened.

9. The Die. — The die is made of tool steel with holes drilled and countersunk to correspond with the bolt holes in the frame. The die hole is made to fit the punch with a minute amount of clearance and countersunk on the underside. Holes are drilled and tapped in the die plate for the screws holding down the stripper plate. This plate is of cold-rolled steel and is made as shown in the drawing.

10. Assembling the Press. — The ram guide is bolted to the frame and the cam held in place. The distance between the cam and the guide is measured and a piece of 1-in. pipe faced off to fit into that position. The frame is smoothed where the cam rubs to give both sides firm bearing. The ram is then put in place through the hole in the base of the frame and through the guide. The die plate is put in place and the punch fastened in the ram. In order to locate the hole to be drilled through the ram for the pin, the cam is put in place over the ram with the handle in the uppermost position and a 5/16-in. block between the punch and die plate. Scribe on the ram through the hole in the cam. Remove the ram, locate the center so that the hole will pass through the axis of the ram and then drill 5/8 in. Reassemble all parts, put the pin in place through the cam and ram, and insert cotters. Inspect all parts. Make the necessary adjustments so that the ram will move easily down and up. Lubricate the moving parts. When punching metal, slip a 4-ft. length of 1¼-in. pipe over the cam lever.

QUESTIONS

1. Where have you observed the use of a cam in machinery?
2. Make drawings of the different shapes of cams you know.
3. By how many methods may friction between the rubbing parts be reduced?
4. Does roller contact eliminate friction? Why?
5. How is it that oil reduces friction between rubbing surfaces?
6. What substances, other than oil, are used to reduce friction? Why?
7. How many grades of oil can you name?
8. Why are holes punched instead of drilled?
9. Is it possible to punch a hole through a metal thicker than the diameter of the punch?
10. Are punches prevented from breaking by a very slight increase in size upward?

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